Heating Piping & Air Conditioning

DESIGN
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SEPTEMBER ★ 1948

INDUSTRIAL
COMMERCIAL
INSTITUTIONAL AND
PUBLIC BUILDINGS

107—Journal Section of the American Society of Heating and Ventilating Engineers

Office building air conditioning system provides control flexibility . . . page 71

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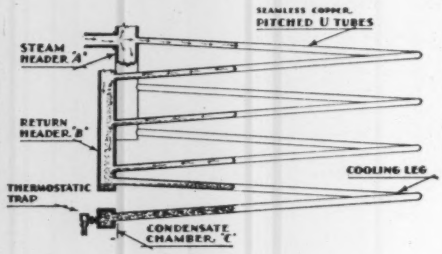

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WHENEVER **PIPING** IS INVOLVED

THE EDITOR'S PAGES

STEEL PIPE SHIPMENTS NEARLY 11 PERCENT UP

Shipments of steel pipe and tubes totaled 3,302,748 tons during the first six months of 1948, an increase of 10.7 percent over the record shipments of the first half of 1947, according to the committee on steel pipe research of the American Iron and Steel Institute.

The committee points out that a continuance of the high rate of shipments during the remainder of 1948 would result in a new annual record. The 1947 total of shipments of pipe and tubes was 6,117,884 tons, larger than ever before in war or peace.

The pipe and tube shipments of the first half of 1948 were 10.2 percent of total steel shipments. That compares with 9.7 percent for 1947, 9.5 percent for 1946. The average for the last 20 years has been about 9.5 percent, the committee says.

Exports of pipe and tubes have not been excessively large since the end of the war, according to the committee. Statistics compiled from Department of Commerce reports on foreign commerce and navigation of the United States show that exports of seamless and welded pipe other than casing, oil line pipe, and boiler tubes were 2.9 percent of pipe and tube shipments during 1947, which was as low or lower than any year starting with 1940 excepting 1945, when the ratio was 2.4 percent. Exports of the above kinds of material, which is largely what is commonly known as merchant pipe, totaled 180,077 tons during 1947.

CONSTRUCTION VOLUME SETS HALF-YEAR RECORD

Investment commitments for construction in the 37 states east of the Rocky Mountains soared to $4,766,795,000 in the first half of this year to set an alltime dollar record for a first-half period, according to the F. W. Dodge Corp.

The previous record for a first-half period was $3,937,736,000, established in 1946.

Contract volume in the first six months of this year was 36 percent higher than that reported for the corresponding period of 1947. The greatest gains were in nonresidential building, which showed a rise of 60 percent. Residential awards were 24 percent higher than in the first half of last year, while heavy engineering works showed a gain of 26 percent.

THINGS ARE GETTING AWFULLY COMPLICATED

When inaudible sound is used to detect invisible light, it seems to be safe to say that things are getting awfully complicated.

According to the University of Illinois Alumni News, Prof. William J. Fry and others in the ultrasonics group of the electrical engineering department have found that infrared rays can be detected by their effect on a gas confined between two vibrating quartz crystals.

The arrangement is called an acoustical interferometer.

15 Years Ago

Featured in the September 1933 issue of HPAC was a plan proposed by Russell Grinnell for the expenditure of a portion of the $3.3 billion (seemed like a lot of money in those days) appropriated by the government for public works. The plan recommended that heating, power, plumbing, electrical, and allied equipment in existing public buildings be modernized where such modernization would prove self-liquidating within a reasonable time. Prominently displayed on one of the pages of this story was our NRA "we do our part" eagle . . . remember?

* * * * *

Leadoff article in that issue was devoted to the use of unit heaters for "effective plant heating with economy" . . . still a good subject. . . . There was also a feature article by Sabin Crocker on the status of piping standardization at that time, not only telling the story but interpreting it. . . . R. H. Heilman contributed an excellent article on heat loss from copper piping, showing tables of heat transmission from pipe and tubes and discussing insulation and lacquering. . . . An article by M. O'Connell described the "modernizing by air conditioning" of six floors in a New York building for a large tenant.

AT LEAST $15 MILLION FOR BUILDING RESEARCH

At least $15 million a year is being spent by the building industry on organized technical research designed to lower the cost and improve the quality of housing and other construction, according to a study made by economists of the Construction Industry Information Committee. Moreover, large additional amounts are being spent for construction research by universities, technical colleges, and institutions, and another $1.5 million by federal agencies, the committee said recently.

"This large annual outlay results in a steady stream of new building products, improvements in the quality and performance of existing products, and improved methods of combining individual building materials in such a way as to raise the quality of finished structures.

"While there is pressing need for expansion of building research, accomplishments to date have been far more spectacular than the public realizes.

"Among the many completely new products developed in the industry's extensive research program are gypsum board, fluorescent lighting, baseboard, and radiant heating, glazed structural tile, new types of insulation, laminated wood arches, and glass block," according to the committee.

INDUSTRIAL HYGIENE NEWSLETTER AVAILABLE

The official publication of the Industrial Hygiene Division, U.S. Public Health Service—the monthly Industrial Hygiene Newsletter—has recently been placed on the list of subscription publications by the Government Printing Office.

It is sent free to persons engaged in industrial hygiene in governmental agencies (federal, state, or local) and is for sale to others by the Superintendent of Public Documents, Government Printing Office, Washington 25, D. C., for $1 a year (domestic) and $1.25 (foreign).

THE EDITOR'S PAGES

LAUNCH PROJECT TO INCREASE NATURAL GAS

Peak load problems have been a major concern of the gas production research program of the American Gas Association. Manufactured gas plants and large pipe line systems today are operating at capacity loads with the demand for gas increasing. In many instances pipe lines are transporting natural gases containing 10 percent or more of noncombustible nitrogen. Large reserves of natural gas have been developed in some areas which have been limited because of the low heating value resulting from high nitrogen contents. Removal of a large part of nitrogen from this natural gas would greatly increase the present capacity of these pipe lines, enabling them to carry a greater quantity of natural gas of higher heat value.

The U. S. Bureau of Mines and the AGA have undertaken a cooperative study of the removal of nitrogen from natural gas. More than $100,000 will be spent on a project intended to increase transmission capacity of natural gas pipe lines and to improve marketability of natural gas containing noncombustible nitrogen.

The Bureau of Mines is interested in nitrogen removal because of its close association with operating problems at the bureau's helium plants. The AGA has undertaken this project as one phase of its expanded research program which calls for expenditures of $1.8 million over a three year period on the problems of gas production and utilization.

ANNOUNCES EARNINGS FOR SECOND QUARTER

Allis-Chalmers Mfg. Co. announced last month net earnings for the second quarter of 1948 of $3,793,723, which, after preferred dividends and provision of $2,520,000 for estimated federal income taxes, were equivalent to $1.39 a share of common stock.

Net earnings for the first six months of 1948 were $6,306,658, or $2.28 a share of common stock after preferred dividends and provision of $4,200,000 for estimated federal income taxes. Because of the strike at the West Allis works which ended March 24, 1947, the net income for the six months ended June 30, 1947, amounted to $475,941 after provision for federal income taxes of $360,000.

NATKIN HEADS HOUSTON GROUP

The Air Conditioning Contractor's Association of Houston has elected new officers as follows:

Al Natkin, president, Natkin & Co.

L. C. Way, vice president, Way Engineering Co.

H. C. Will, secretary, J. A. Walsh & Co.

M. G. Gebhart, treasurer, Airtex, Inc.

Highlights of the meeting included a desire to improve air conditioning installation standards and to establish recommended designs and practices for the Houston area.

INDIA'S FIRST THREE RAYON PLANTS AIR CONDITIONED

The first three rayon producing plants in India's history will all be equipped with air conditioning systems, the Carrier Corp. international division has announced.

The latest India contract for process refrigeration and air conditioning has been received from the National Rayon Corp., Ltd., of Bombay. Ground for National Rayon's new spinning mill has already been broken at Kalyan, 30 miles from Bombay. The mill will produce annually about 5,000,000 lb of viscose yarn when operations begin next year.

This production, coupled with that of Travancore Rayons, Ltd. and Sirsilk, Ltd., will substantially relieve India's rayon yarn shortage. National Rayon's mill is being designed so a production of 10,000,000 lb annually can be attained without major changes in the chemical process layout.

Principal refrigeration equipment to be furnished will be a pair of centrifugal machines totalling 1200 hp.

Want Reprints?

Several subscribers have asked about reprints of the entire series of arficles by John Clarke, entitled Design Engineer Reports on Operating Experience, publication of which concluded in the May issue. If the demand is great enough, reprints will be prepared. It would be helpful in judging the demand for reprints if all those who might want them (for a nominal charge) would advise The Editor, Heating, Piping & Air Conditioning, 6 N. Michigan Ave., Chicago 2.

PRODUCTION SETS NEW HIGH MARK

Production of the Westinghouse Electric Corp., as represented by net sales billed, hit a new record high of $424,456,102 during the first six months of 1948, Gwilym A. Price, president of the company, has reported. This was a 7 percent increase over the previous high set in the same period of 1944 when the country was at war. Output during the first six months of 1947 totaled $312,338,636.

In dollar volume, the company's net profit for the first six months of this year amounted to $24,941,100, equal to $1.83 a share on outstanding common stock. This compared with net profit of $21,735,442 or $1.59 a share on common stock in the same period of 1947. Net profit for the quarter ended June 30 was $11,805,311 compared with net profit of $10,675,247 in the second quarter of last year.

Net earnings for the first six months amounted to 5.9 cents from each dollar of net sales billed. This compared with 7 cents from each dollar of sales billed in the first six months of 1947. Higher costs for labor and materials, together with price reductions made during this period, were directly responsible for this decrease, Mr. Price said.

Unfilled orders on hand at the end of June totaled $686,615,274 compared with $673,496,915 on June 30, 1947. Orders booked during the first six months totaled $467,753,265 compared with $418,118,817 for the same period of 1947.

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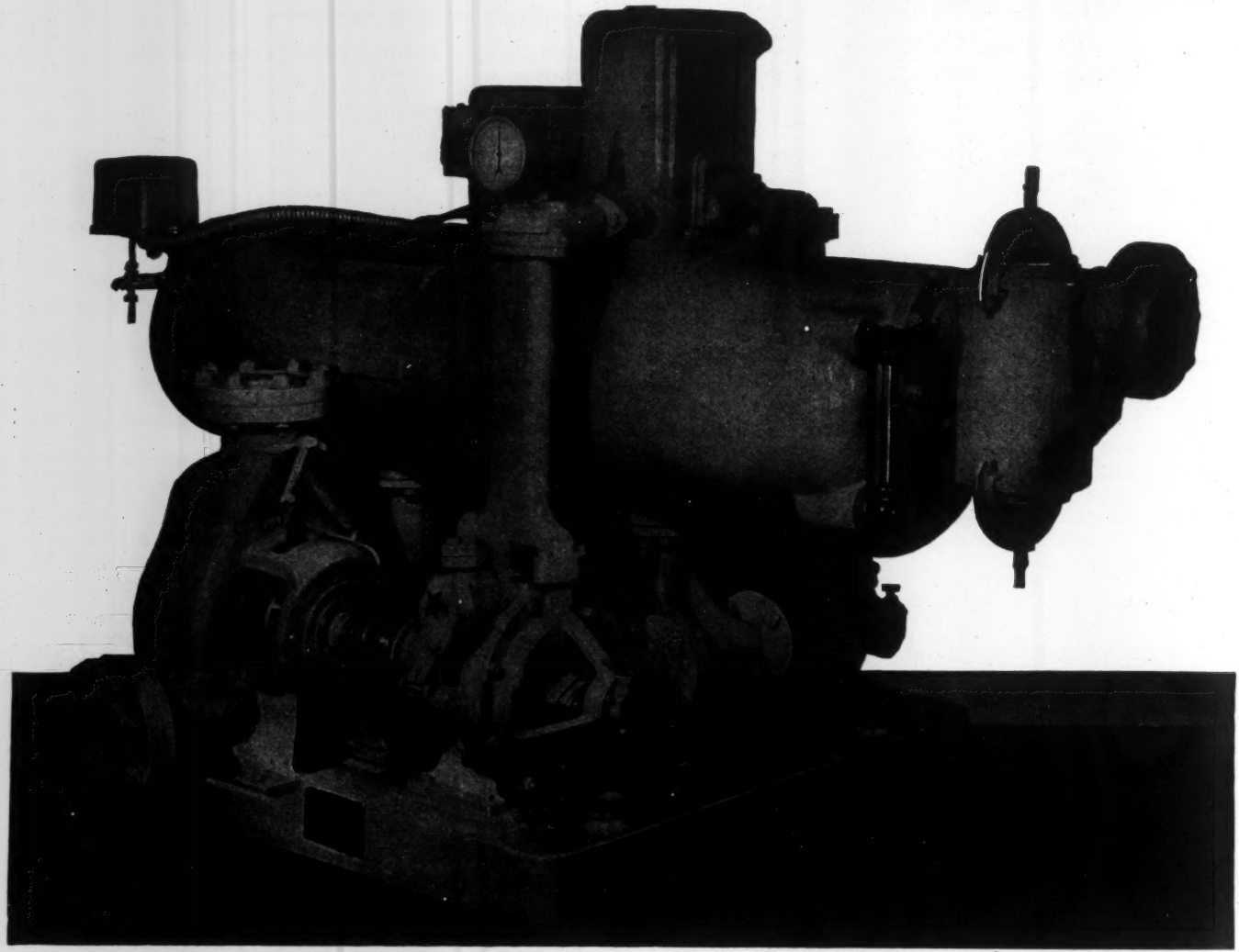
Where Heat Must Not Fail--
Install this SAFE Heating Pump!



In Hospitals, Greenhouses, Schools, Public Buildings, Theatres, wherever heating systems must not fail, install the Nash Vapor Turbine, for it is entirely independent of electric current failure, and continues to operate as long as there is steam in the system.

More than that, the Vapor Turbine is a most economical pump, for the elimination of electric current does away with current cost, the largest single item in the operation of an ordinary return line heating pump.

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THE NASH ENGINEERING COMPANY

SOUTH NORWALK, CONNECTICUT, U. S. A.

General Petroleum's new office building in Los Angeles has approximately 1000 independently controlled rooms

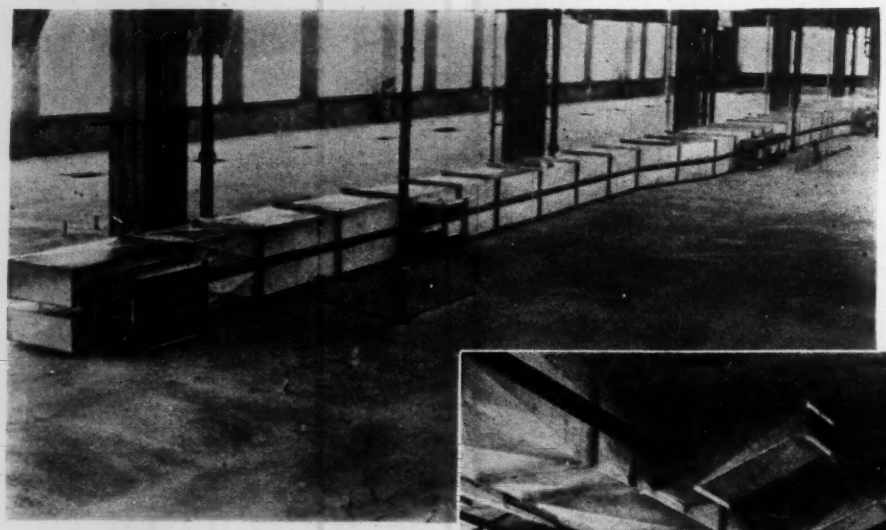
Individual Control, Flexibility in Office Building Air Conditioning

RALPH E. PHILLIPS, consulting mechanical and electrical engineer, and LOUIS H. WAGENBRENNER, chief mechanical engineer, Los Angeles, describe the features of the air conditioning for the new General Petroleum Corp. office building in that city. A double duct (hot and cold air) system is used to permit individual control of conditions in each room. A novel architectural feature is the use of vertical fins projecting out from the face of the building between each pair of windows; it is estimated that they reduce the cooling load about 100 tons by the saving in sun load

WURDEMAN AND BECKET, prominent Los Angeles architectural firm, was commissioned to design an office building for the General Petroleum Corp. which was to be of limit height and have a gross floor area larger than any office building in that city. The owners wished complete flexibility so that changes of department layouts could be easily and economically accomplished. It was also required that certain floors be set aside for outside rental. It is quite obvious that, aside from the architectural problems involved, these requirements very seriously involve the mechanical and electrical systems in the building.

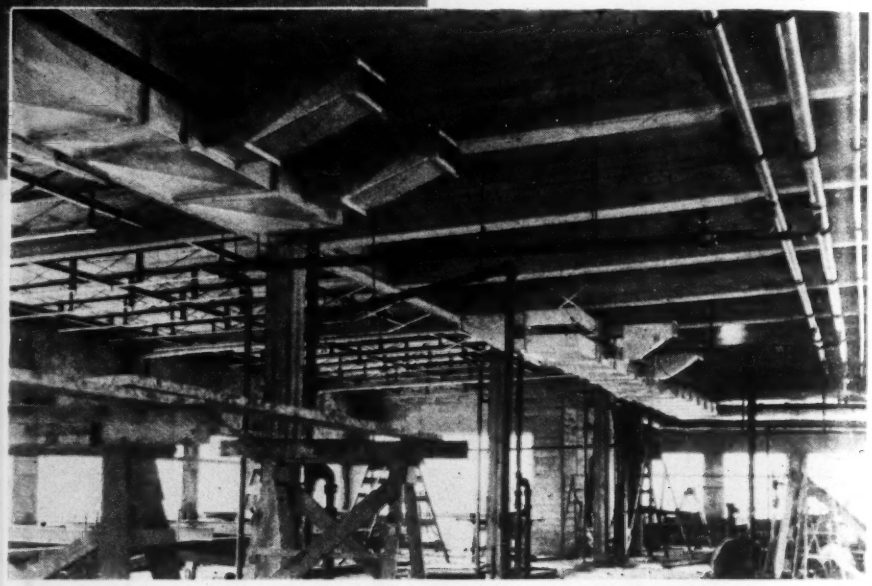
Basically, the building is designed architecturally and structurally so that office spaces are based on 14 ft modules, with two windows per bay, allowing each bay to be split into two if necessary. It was decided to provide for 7 ft bays on the rental floors and 14 ft bays on the floors occupied by the owners.

The owners desired that the entire building be soundproofed from outside street noises, making better working conditions for the employees. This requirement made it necessary that the building be air conditioned. The owner also wished that the air conditioning system be designed in such a manner that, regardless of exterior and interior load conditions, comfortable temperatures could be maintained in each individual office. Due to the Los Angeles climate, it is not uncommon, during winter months, to



Left: For temperature control in each office, a double duct system—one for cold air and one for hot air—is used. This view shows typical construction of the double duct on the floor before being erected at the ceiling

Below: This is a typical view of part of the double duct system installed



be heating some portions of the building while cooling others.

From an economic viewpoint—considering rentable office spaces—the proper design of an air conditioning system is an item of utmost importance. Due to the increased fire hazard of a vertical duct system, the final conclusion was to establish four fan rooms per floor. This decision was based on the fact that the city of Los Angeles has a limit height building law restricting all buildings to 150 ft from the sidewalk to the top floor ceiling. The owners decided to incorporate 13 floors in this height. Due to these requirements and the consequent limit in floor to floor dimensions, it was necessary that extreme caution be exerted in the design of the ducts and equipment rooms in order to maintain reasonable ceiling heights.

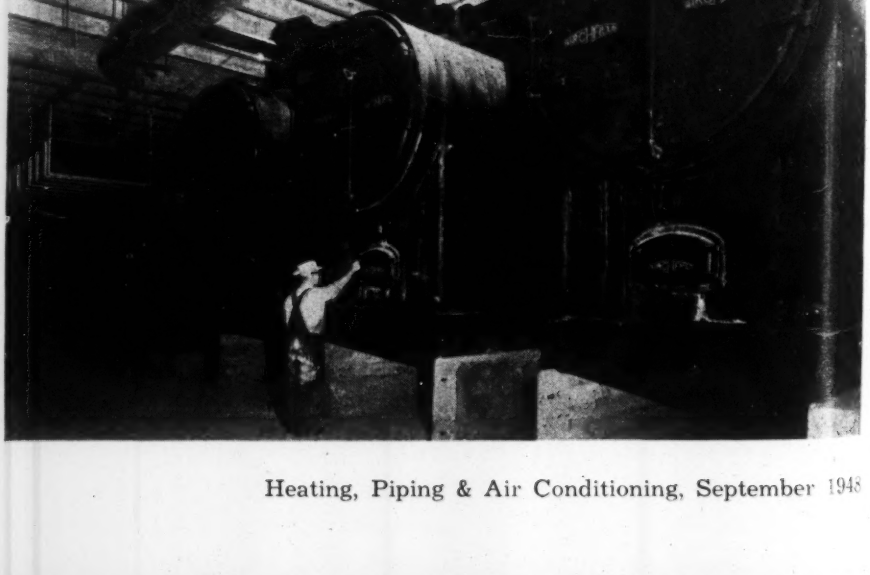
1000 Independently Controlled Rooms

Because of the requirement of temperature control in each office, it was decided to install a double duct system with hot air being distributed in one duct and cold air being distributed in the other, thereby permitting either hot or cold air or a mixture of both to be distributed into each office as required to maintain the desired room temperature. The double duct system was installed in the corridor ceilings, with branch ducts at approximately 14 ft centers in the space occupied by the owners and at 7 ft in the rental areas. These branch ducts are connected to ceiling supply outlets in the office spaces.

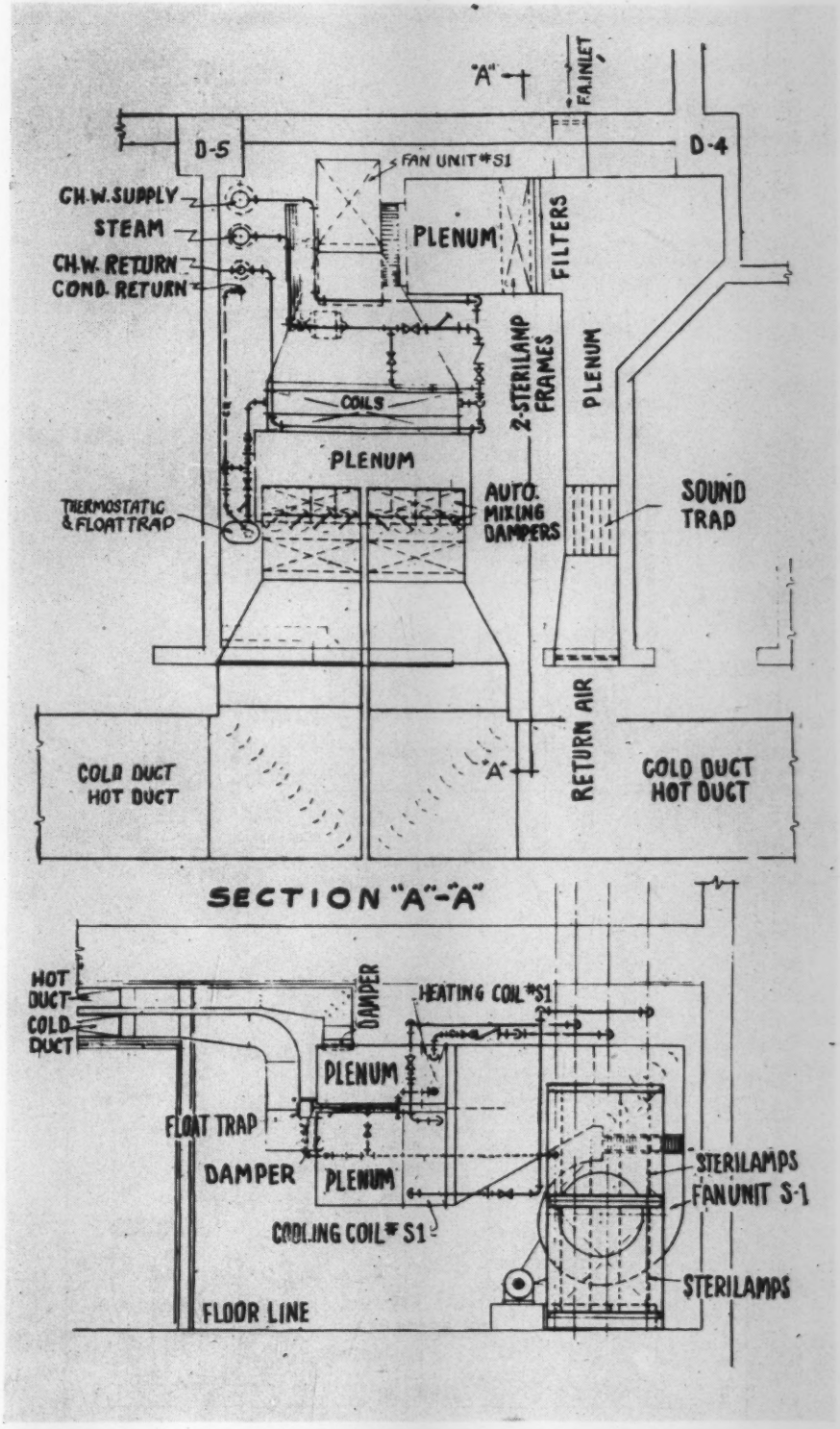
This caused further difficulties in the rental spaces, as the dimension from the outside wall to the corridor wall is 21 ft, making it possible to have an office 7 ft wide and 21 ft long. For the correct diffusion of air in these rooms, outlets which split the air in a one-third—two-thirds ratio (the two-thirds amount directed against the outside wall or window and the one-third amount directed toward the interior wall) are used.

The branch duct to each office is connected to both the hot air and cold air duct located in the corridor

The four 21,250 sq ft EDR boilers are fired with combination fuel oil and gas burners. There is a fifth boiler of smaller size to furnish steam for domestic hot water only during the non-heating months



Typical layout, fan room No. 1, 5th to 15th floors. Opposite hand, No. 2 fan room, 3rd to 12th floors



ceiling. Automatic dampers were installed in each of these connections and then a single duct run to each supply outlet. These automatic dampers are controlled by a room thermostat, thereby permitting each room to be independently controlled. Consideration was also given to the location of the branch duct take-offs from the trunk ducts in the corridor ceiling so that access panels in the corridor ceiling would occur at regular intervals, also at points to meet the acoustic tile ceiling pattern, and (where possible) to provide one access panel for two branches. Approximately 1000 independently controlled rooms were provided for.

Due to the mildness of the Los Angeles climate for winter heating, no system of direct radiation was considered and all of the heating will be accomplished through the air conditioning system.

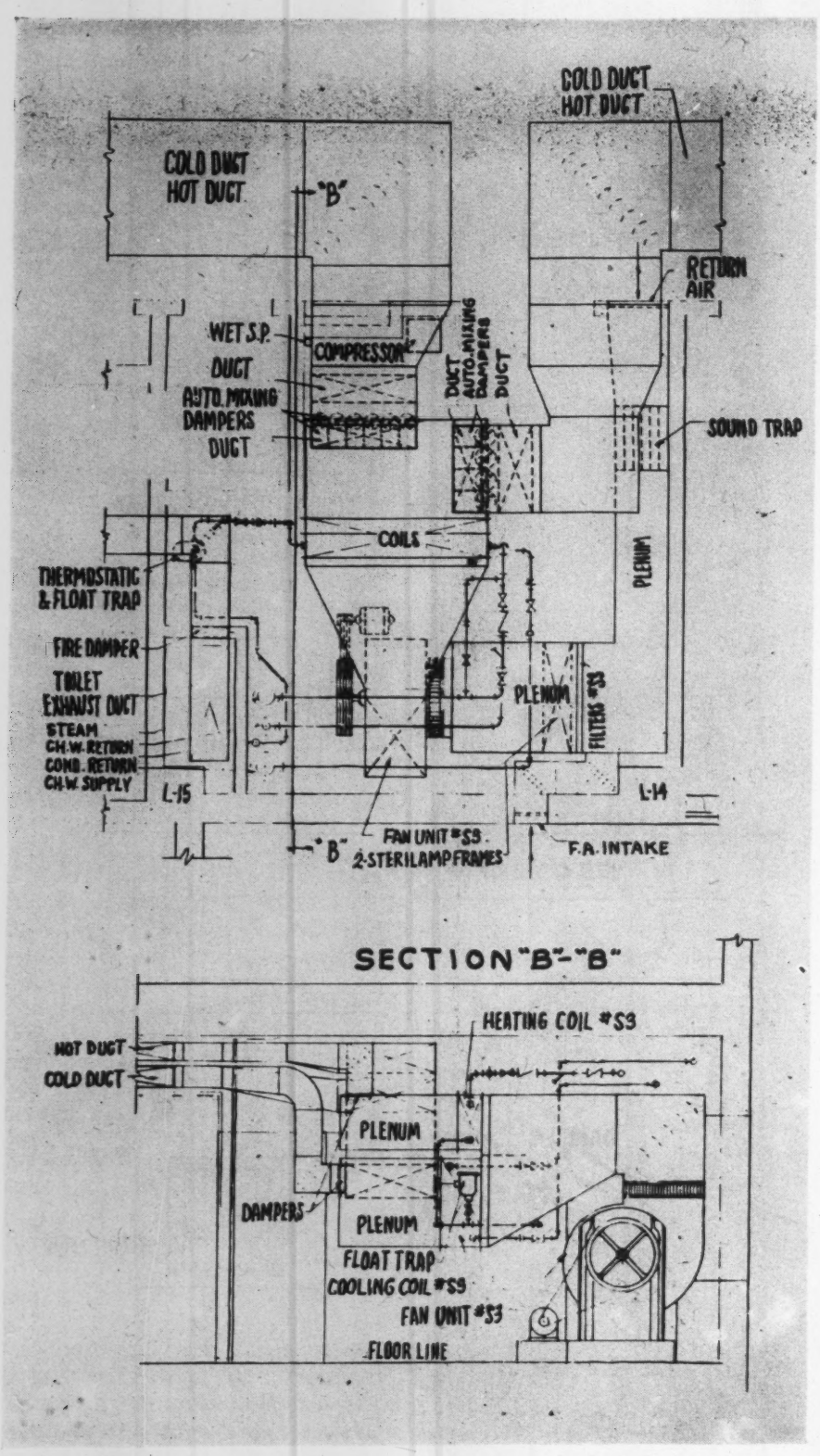
Each Fan System Supplies 20 Rooms

Each fan system supplies air to approximately 20 independently controlled rooms. Consideration was given to possible unsatisfactory results if, for example, 90 percent of the rooms were calling for heating and 10 percent for cooling, due to internal conditions of increased population or light load; or if 90 percent of the rooms called for cooling and 10 percent called for heating due to individual requirements of the occupant. In order to assure constant pressure and velocities at each outlet, regardless of the proportion of the quantities of hot or cold air flowing in their respective ducts, a differential static pressure regulator was installed on each fan system. A static head was installed at the center of run of each hot and cold trunk line. The regulator actuates louver dampers at the face of each hot and cold coil to maintain a constant minimum differential between the air pressures in the two ducts as measured at the static heads.

Consideration was also given to office areas larger than 14 by 21 ft, requiring only one room thermostat to control the area involved. This was accomplished by the use of a loop connector allowing the mixing dampers for each branch duct to be operated by one of the room thermostats. The unused thermostat locations were provided with a blank plate. If, in the future, these spaces are cut up into smaller offices, the blank plates can be removed and thermostats installed at that time.

The automatic temperature control system is of the pneumatic type.

As the building is in the shape of a block figure eight with two light courts, it is possible to draw the outdoor air intake into each fan room from these light courts. Each system was designed for approximately 25 percent outside air and 75 percent return air. The air from each office is returned to the main corridor by means of louvers over each door and thence through a return grille at the entrance to each fan room. The return air duct from



Typical layout, No. 3 fan room, 3 d to 13th floors

this grille to the fan inlet was provided with a sonic filter which will eliminate transmission of noise from the fan room to the corridor. The fan room walls were also treated with sound absorbing material.

A bank of filters and germicidal lamps are provided for in the suction chamber to each fan, allowing both the outdoor air and the return air to be filtered and sterilized. On the discharge side of each fan separate heating and cooling coils are provided for. These coils are located one above the other, permitting a hot plenum chamber and a cold plenum chamber. The hot plenum temperature is automatically controlled at the level required by the heating load. This provides a higher delivered air temperature when required for warm-up period or extreme heating demand. The cold plenum is maintained at a constant temperature by the chilled water system.

Uncommon to problems of air conditioning in eastern and southeastern climates—which involve considerable latent heat removal—Los Angeles, with few exceptions, requires principally sensible heat removal, which with the closed coil chilled water heat exchange system will make it possible from an operating standpoint to modulate water temperatures as outside conditions require. Therefore, it was decided to operate the chilled water plant by manual control. A wet and dry bulb recorder in the engineer's office permits the operator to read the outside temperatures.

Three 300 Hp Centrifugals

The refrigeration plant for the building is in the basement and consists of three 300 hp centrifugal compressors using "Freon 11" refrigerant and having a capacity of 333 tons each. The compressors are provided with automatic load control from full load to 25 percent full load. Starting and stopping of each machine is by manual control. There are four chilled water pumps with suction connections to a common header from the shell and tube coolers and discharge connections to a common header with separately valved lines to each bank of fan rooms (which are located one above the other at each floor), and returning back to the coolers through balanced vertical loops.

Condensers are of the shell and tube type with condensing water being cooled by means of an eight cell induced draft cooling tower on the roof of the building and completely surrounded by a sign structure for architectural appearance. A separate condensing water pump was provided for each condenser, with each pump discharging into a common header to the tower and back from the tower through a common return line with separate connections to each condenser.

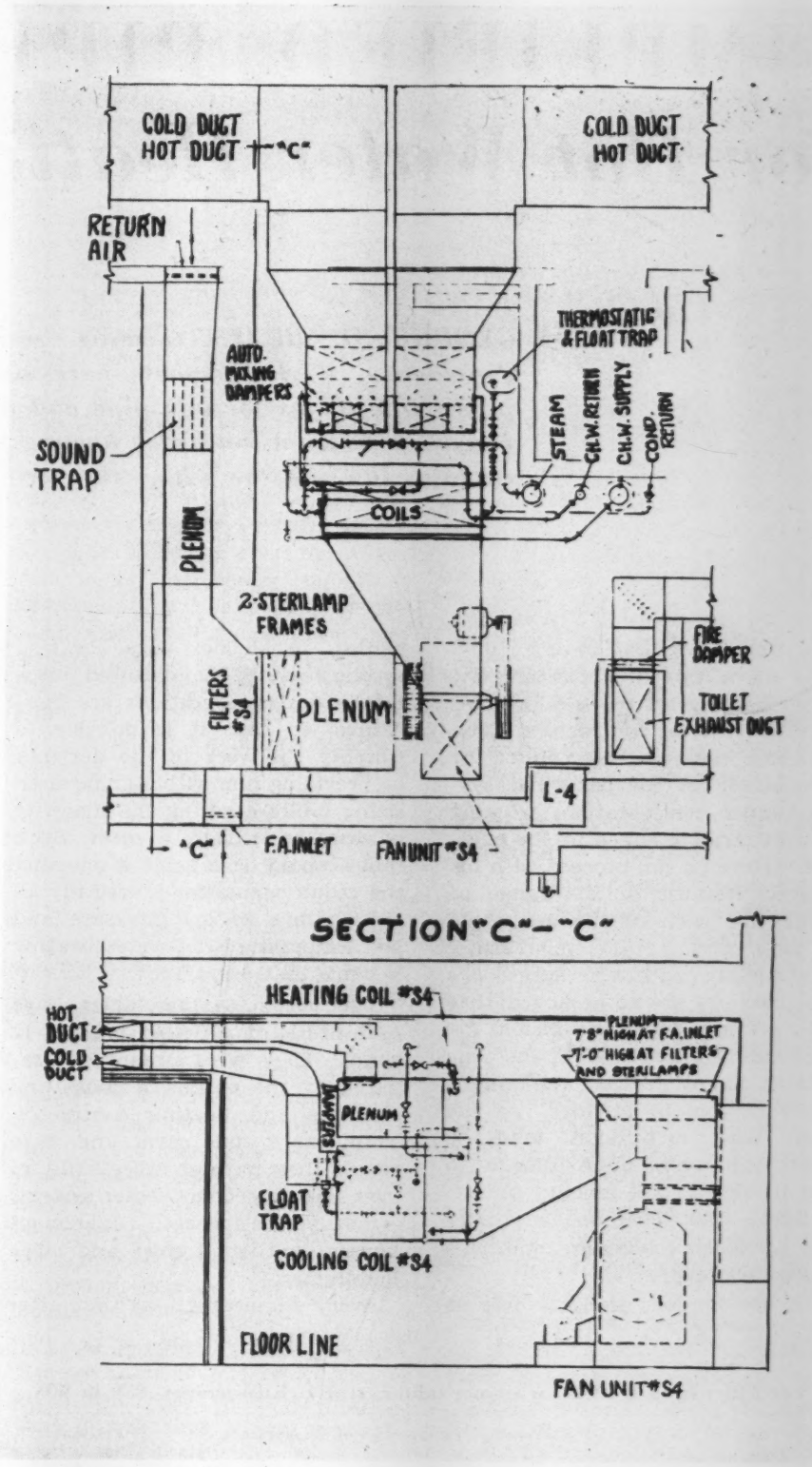
Typical layout, No. 4 fan room, 5th to 9th and 11th to 13th floors

The heating plant consists of four low pressure, firebox, portable, steel boilers having a capacity of 21,250 sq ft EDR each. Steam is supplied to the heating coils at approximately 2 lb ga pressure with condensate being returned by means of a vacuum return system. Each boiler is equipped with fully automatic combination fuel oil and gas burners. In addition to the four heating boilers, a fifth boiler of smaller size for operation during non-heating months furnishes steam for domestic hot water only.

From the second to the 13th floor inclusive, there are 48 fan rooms. Each fan handles approximately 7500 cfm and is driven by a 3 hp motor. Each office is provided with a minimum of six air changes per hour. The average air change amounts to approximately eight per hour.

The entire ground floor will be used for store rentals, and was left in abeyance until such time as the character of the rental has been established. If air conditioning is desired by the tenant, separate systems will be installed independent of the main building system. However, a loop steam main is provided on the basement ceiling for the store spaces, which will simplify off-hour operation with one boiler when heating is not required for the balance of the building.

The temperature control system for this building is unusually extensive due to the independent room control, double duct system, and the size of the structure involved, but, surprisingly, the total cost of the system compared very favorably with conventional duct designs zoned for exposure only.



Architectural Fins Reduce Sun Load

An interesting architectural feature is the construction of vertical fins extending from the second floor level to the roof and located between each pair of windows. These fins are of light metal construction and project out from the face of the building approximately 4 ft. These fins not only lend a most modern architectural appearance to the building, but serve a very practical purpose by reducing solar radiation on the walls and glass. The building is located on an axis having northeast, southeast, southwest, and northwest exposures. Solar radiation was eliminated on the northwest exposure, which is the most severe in this latitude, especially on glass. There was an approximate saving of 100 tons of refrigeration due to the elimination of this sun load and consequently a saving in the cost of operation.

[The architect for this project is Wurdeman and Becket, the general contractor is P. J. Walker Co., and the heating and air conditioning contractor is W. S. Kilpatrick & Co. Ralph E. Phillips is the consulting mechanical and electrical engineer.]

SIMPLIFIED PIPE SIZING *for Hot Water Heating Systems*

***GEORGE D. BEALS**, heating contractor, Providence, R. I., presents here simplified pipe sizing tables for one pipe and two pipe forced circulation hot water heating systems, explains the basis on which they are figured*

HEAT CARRYING capacity of a supply pipe for a forced circulation hot water heating system is dependent upon several varying factors. Each of these must be determined by calculation for the particular system under consideration, or must be arbitrarily assumed by the engineer before he can proceed with his design. Because of the range of values for each of the applicable factors, most of the pipe sizing tables published in reference books and catalogs are so arranged that they give the designer sufficient information to satisfy all of the conditions of any problem that might confront him in practice. At the same time, such detail tends to make the tables more difficult to use in view of the amount of calculating that must be done after the particular job design conditions are determined.

In my opinion, probably over 90 percent of all hot water heating systems may be standardized, insofar as design conditions are concerned, so that it is possible to simplify the work of the designer by providing him with standardized sizing tables covering the majority of cases he is likely to meet. Such tables would be capable of meeting the requirements for practically all installations of low pressure and low temperature hot water heating systems that are made.

The accompanying tables have been in use for a period of about 12 years. They were originally prepared by the author, a consulting engineer and heating contractor, simply as a time saver and have served their purpose successfully in over 1000 forced hot water systems —mostly residences, apartment houses, and small store and office buildings.

Every engineer knows that after carefully calculating radiator sizes, pipe diameters, pump capacities, horsepower requirements, and other components of a hot water heating system he has had to compromise his results sometimes as much as 50 percent in order to meet the standard ratings of commercial products available to him. This being the case, time-saving sizing tables that will quickly and accurately give him the answer to most of his everyday problems should prove of value.

Heat Carrying Capacity of Pipe

The carrying capacity of a supply pipe for a forced circulation hot water heating system may be calculated by the following formula

$$D = \frac{R \times H}{W \times T \times M \times V \times G \times K}$$

where D = area of pipe, sq ft; R = emission rate per sq ft of radiation for the given water temperature, Btu per

Capacities in sq ft EDR for copper tubing, type L, hard temper, 250 lb WP

Pipe size, in.	Gpm	Average radiator water temperature, F: 215	197	190	175	Friction head, ft per ft of pipe
		Emission rate per sq ft radiation, Btu per hr: 240	200	180	160	
1	9.01	325	390	430	485	0.045
1¼	13.72	515	620	690	775	0.035
1½	19.45	720	865	960	1080	0.029
2	33.8	1250	1500	1665	1875	0.020
2½	52.3	1925	2310	2570	2890	0.015
3	74.4	2750	3300	3670	4120	0.013
3½	100.8	3700	4450	4940	5550	0.011
4	130.8	4790	5750	6400	7200	0.009
5	204.	7450	8950	9950	11200	0.008
6	285.5	10670	12800	14200	16000	0.007
8	512.	18700	22400	24900	28000	0.005

For a temperature drop of 30 F in the system, the above capacities may be increased 50 percent.

Valve and riser sizes for copper tubing

Size in.	1st fl.	2nd fl.	3rd fl.
⅜	45	30	25
½	75	50	40
⅝	110	75	65
¾	125	85	75
1	225	160	145
1¼	425	300	275

The riser capacities given above are for one pipe or two pipe systems, upflow or downflow, and with a flow fitting on the return end only of one pipe systems.

Capacities in sq ft EDR for standard weight steel pipe

Pipe size, in.	Gpm	Average radiator water temperature, F: 215	197	190	175	Friction head, ft per ft of pipe
		Emission rate per sq ft radiation, Btu per hr: 240	200	180	160	
1	9.43	340	410	450	510	0.068
1¼	16.3	590	710	790	885	0.046
1½	22.4	805	965	1075	1210	0.036
2	36.7	1320	1580	1760	1980	0.027
2½	52.2	1880	2260	2500	2820	0.021
3	80.6	2910	3490	3880	4360	0.016
3½	107.9	3880	4650	5170	5820	0.013
4	139.	5000	6000	6670	7500	0.011
5	218.5	7880	9450	10500	11800	0.009
6	315.5	11370	13650	15150	17010	0.008
8	558.	20100	21100	26800	30200	0.006

For a temperature drop of 30 F in the system, the above capacities may be increased 50 percent.

Valve and riser sizes for steel pipe

Size in.	1st fl.	2nd fl.	3rd fl.
½	90	60	50
¾	150	100	90
1	250	175	160
1¼	500	350	320

The riser capacities given above are for one pipe or two pipe systems, upflow or downflow, and with a flow fitting on the return end only of one pipe systems.

hr; H = heat load, sq ft of radiation; W = weight of 1 gal of water at the given temperature, lb; T = design temperature drop in the system, F; M = 60 min in 1 hr; V = velocity of water, fpm; G = gal of water per cu ft at the given temperature; and K = factor of safety constant to cover the miscellaneous heat losses in the system.

The accompanying sizing tables are based on arbitrarily assumed values of 210 fpm water velocity, a temperature drop through the system of 20 F, four conditions of average water temperature (215, 197, 190, and 175 F), and a factor of safety constant of 0.9 to cover the miscellaneous heat losses. The water velocity of 210 fpm is recommended where the noise of flowing water within the piping system would be objectionable and where excessive friction head losses are not desirable. For distributing mains outside of a building, velocities as high as 400 to 500 fpm may be used. Practice has shown that a temperature drop of 20 F throughout a system of medium size has proved satisfactory. This means that the boiler water temperature will be 10 deg higher than the average radiator water temperature as shown in the tables and the limit controls governing the operation of the boiler should be set at this point.

To calculate the gallons of water necessary to carry the given heat load, the following formula may be used:

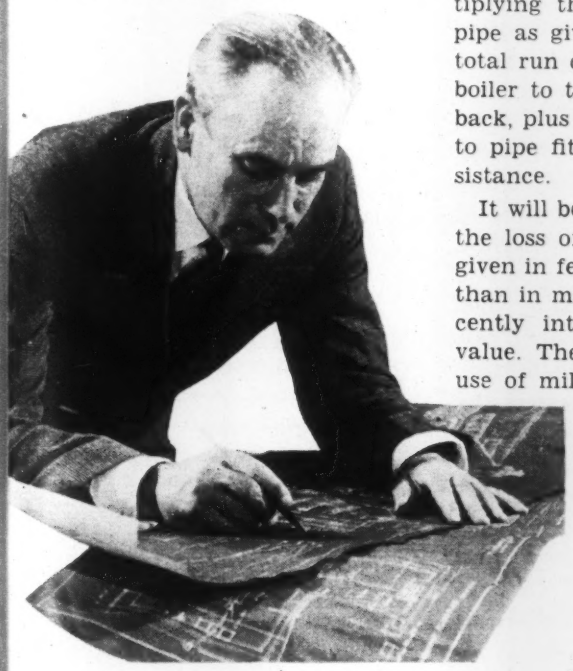
$$P = \frac{R \times H}{T \times M \times W \times K}$$

where P = gpm of water at the given temperature, and the other factors are as specified above.

Calculating the Friction Head

The total friction head against which the circulating pump must operate may be obtained by multiplying the head loss per foot of pipe as given in the tables by the total run of pipe, in feet, from the boiler to the farthest radiator and back, plus 50 percent for losses due to pipe fittings and the boiler resistance.

It will be noted in the tables that the loss of head due to friction is given in feet per foot of pipe rather than in milinches, a term more recently introduced to express this value. The reason advanced for the use of milinch in calculating head losses is that it expresses values less awkward to handle mathematically than the generally accepted feet of head. However, it would seem much simpler to use 1 ft of head than its equivalent 12,000 milinches, or 0.05 ft of head rather than 600 milinches.



The tables have been used for over 1000 installations

These sizing tables are applicable for either one pipe or two pipe heating systems. In the case of the one pipe system, they may be used for either the system employing a diverting fitting in the main or for the so-called "choker" system.

MINERAL WOOL STANDARD REVISED

The standing committee in charge of reviewing Commercial Standard CS105-43 (Mineral Wool: Loose, Granulated or Felted Form, in Low Temperature Installations) has approved a revision of this standard and the National Bureau of Standards has mailed copies of the recommended revision to manufacturers and other interested groups for their consideration and written acceptance.

This standard was first issued in 1943 and covered loose, granulated, and felted forms. The recommended revision has been expanded to include mineral wool boards and blocks and contains descriptions with five new illustrations showing construction methods for using them. Requirements for moisture sorption, corrosive properties, odor, fire resistance, cold asphalt mastic, asphalt emulsion, and reinforcing membranes are now included in the standard.

A limited number of mimeographed copies of the recommended revision are available, and a copy may be obtained as long as the supply lasts, from the Commodity Standards Div., National Bureau of Standards, Washington 25, D. C.

Methods of Making

PIPING FLEXIBILITY

Analyses

UNIVERSITY OF MICHIGAN LIBRARIES

PRIMARY FUNCTION of piping is to convey vapors, gases, or liquids from one process point to another under varying pressure and temperature conditions. Generally, piping systems contain and are attached to mechanical appliances which assist in the operation and control of the process. Due to thermal expansion, pipes develop forces which if not properly evaluated and controlled may affect operation of the equipment. Plant shutdowns requiring frequent pump repacking, gasket, stud bolt, pipe, or equipment replacement may in many instances be attributed to thermal overstrain.

Economics and hydraulic considerations of larger units require bigger diameter piping. Corrosion and erosion problems are settled by increasing wall thicknesses or by using alloy steels. These factors when combined tend to increase stress on mechanical equipment.

Piping attached to unhoused process equipment requires special treatment to resist wind forces. Vibrations in piping are generally corrected after installation. Effects of creep and plastic deformation are difficult to evaluate mathematically in piping systems.

To minimize these effects, complete pre-strain of high temperature piping is desirable, although apparently not sanctioned by the code authorities.

This brief resumé indicates roughly our present state of knowledge. Forces from thermal expansion may, however, be evaluated with a reasonable degree of accuracy within certain limits. The purpose of this article is to introduce a new concept of "beam analogy" in determining forces resulting from thermal expansion. The beam analogy is a particular solution of the general concept of "column analogy" and mathematically is a special solution of the general theorem.

F. E. WOLOSEWICK, design engineer, Sargent & Lundy, engineers, Chicago, discusses here the "column analogy" concept of analysis of piping systems, which—since it is elementary—can be broken down into an easily remembered procedure. . . . There are numerous methods of analyzing the flexibility of piping systems and a great amount of material on this important subject has been published. In the June 1946 HPAC, Sabin Crocker and Arthur McCutchan reviewed the various methods, and suggested that the advocates of the different schemes each briefly outline the merits of his method and show the solution of two problems; in this way, the reader can judge for himself the suitability of the different calculation procedures in his own piping work. . . . S. W. Spielvogel followed this suggestion in the July 1946 issue, explaining the essentials of the elastic center method, and in September M. J. Fish discussed the graphical method. In November 1946, W. G. Hooper covered the tabular integration method and solved the two problems given by Messrs. Crocker and McCutchan by that means. In the January 1947 number, R. C. DeHart explained the moment distribution method; H. V. Wallstrom reviewed the general analytical method in May; and in August, Lale C. Andrews discussed a model test method. In September 1947, there was published an article by Henri Carlier, as translated by Mr. McCutchan.

Advantages of Column Analogy

The column analogy concept has certain advantages over algebraic, moment area, and neutral point methods of analysis. Elastic concepts of stiffness and carryover factors may readily be evaluated by this analogy. Another advantage in the use of this analogy lies in adapting a method of thinking consistent with elementary mechanics and strength of materials.

Consider a bend lying in plane and having two points of anchorage, as indicated in Fig. 1a. If end B were free to expand it would move through a distance of Δx, and Δy. Since point B is fixed, two forces F_x and F_y must be acting at the end opposing translation. To prevent angular rotation of the tangent line, a counter-rotation or a moment must be developed at that end. There are then three unknown forces at B, and from sta-

ics the direct forces at both ends must be equal. Moments M_A and M_B are generally unequal, but for special conditions of differential heating, and displacements of anchor points, may be zero or equal.

The bend as shown in Fig. 1a is indeterminate to the third degree. If one end is permitted to rotate freely, moment at that end is zero, and angular deviation occurs as shown in Fig. 1b. For this condition redundancy is reduced to the second degree. By allowing guided displacement in the direction of expansion with restraining moment M_B as shown in Fig. 1c, the force in that direction is zero, and redundancy is reduced to the second degree.

Zero moments at anchor points under operating conditions may be attained through pre-strain of the line, or by rotation of the equipment. The first is desirable, the second undesirable. Rotation of equipment develops forces generally not considered by the equipment manufacturer in his design. Pump or turbine rotation may produce severe vibrations, while rotation of heat exchange equipment generally results in serious local overstrain, causing bad leakages. Nozzle deviations on pressure vessels cause highly localized stresses which in many instances are not serious.

General solution of unknown forces may be attained through the use of virtual work, energy methods, or Castigliano's theorem of least work. All give the same results, except that the multiplying variables are obtained from different philosophical concepts.

Development of Equations

To develop equations forming the column analogy concept, it is simpler to use the existing theories mentioned above than to utilize the general equations of flexure in columns*.

For Fig. 1a, let I = moment of inertia of the pipe; and K = flexibility factor (sometimes called Karman-Hovgaard's factor), in which $K = (12h^2 + 10)/(12h^2 + 1)$. The value of $h = tR/r^2$, where t is the nominal wall thickness, r the mean radius of the pipe, and R = radius of the bend. Δx and Δy are the displacements along the X and Y axes.

The internal work in the bend is expressed by Castigliano's theorem as follows:

$$W = \int M^2 ds K / 2EI \quad \text{.....[1]}$$

The partial differential quotient of work with respect to the unknown forces will be equal to the displacements in the direction of the forces, and to zero in case of rotation. Thus:

$$\left.\begin{aligned} \frac{\partial W}{\partial F_x} &= \int M \frac{\partial M}{\partial F_x} \frac{ds K}{EI} = \Delta x \\ \frac{\partial W}{\partial F_y} &= \int M \frac{\partial M}{\partial F_y} \frac{ds K}{EI} = \Delta y \\ \frac{\partial W}{\partial M_A} &= \int M \frac{\partial M}{\partial M_A} \frac{ds K}{EI} = 0 \end{aligned}\right\} \text{....[2]}$$

From Fig. 1a, the bending moment at any point is:

$$M = F_y x_A - F_x y_A + M_A \quad \text{....[3]}$$

Substituting into equation 1,

$$W = \int (F_y x_A - F_x y_A + M)^2 K ds / 2EI \quad \text{.....[4]}$$

Equation 4 is general for any element of the pipe. For curved segments, the value of K must be attached to that integral. For straight portions of pipe, K is equal to 1, while for corrugated sections K is assumed to be 5. For curved portions, K may vary from 1 to 20 depending on sharpness of radius of bend, thickness of wall, and radius of pipe wall.

Differentiating equation 4, before performing the integration, the following equations appear:

$$\frac{\partial W}{\partial F_x} = \Delta x = \int (M_A - F_x y_A + F_y x_A)(-y_A) \frac{ds K}{EI} \quad \text{----------[5]}$$

$$\frac{\partial W}{\partial F_y} = \Delta y = \int (M_A - F_x y_A + F_y x_A)(x_A) \frac{ds K}{EI} \quad \text{----------[6]}$$

$$\frac{\partial W}{\partial M_A} = 0 = \int (M_A - F_x y_A + F_y x_A) \frac{ds K}{EI} \quad \text{----------[7]}$$

Performing the multiplications indicated in equations 5, 6, 7, and rearranging terms in a manner indicated, the equations become:

$$\Delta x = \int \left(F_x y_A^2 \frac{ds K}{EI} - F_y x_A y_A \frac{ds K}{EI} - M_A y_A \right) \frac{ds K}{EI} \quad \text{----------[8]}$$

$$\Delta y = \int \left(-F_x x_A y_A \frac{ds K}{EI} + F_y x_A^2 \frac{ds K}{EI} + M_A x_A \right) \frac{ds K}{EI} \quad \text{----------[9]}$$

$$0 = \int \left(-F_x y_A \frac{ds K}{EI} + F_y x_A \frac{ds K}{EI} + M_A \right) \frac{ds K}{EI} \quad \text{----------[10]}$$

It will be observed that symmetry of integral coefficients exists about the diagonal running through F_x, F_y, and M_A. Recognition of this fact minimizes computations considerably. This symmetry is explained by Maxwell's law of reciprocal deflections.

Equations 8, 9, and 10 constitute the basis for algebraic solution. The application of the above equations becomes somewhat difficult as the number of segments in the pipe bend increases due to changes of direction. Definite sign conventions must be strictly adhered to. Tabulation of integrals of various pipe elements is required.

The necessary bookkeeping operations have been considerably simplified by numerous investigators. With the aid of calculating machines, the required operations can be performed by personnel with limited technical training. The solutions obtained are to be interpreted by the design engineer in terms of reactions on equipment, stress in the pipe, or thrust at the anchor.

The above equations also form the basis for the grapho-analytical method of analysis. The three forces are applied at one of the free ends, the displacements due to these forces are summed and equated to the respective linear expansions and to zero for angular rotation. The integration is performed graphically over a developed length of the pipe line. Simultaneous solutions are required for evaluation of the forces.

From equations 8, 9 and 10 two analogies may be deduced, the neutral point analogy of Mueller Breslau, and the column analogy of

* Column Analogy, H. Cross, University of Illinois Press; Strength of Materials, George F. Swain.

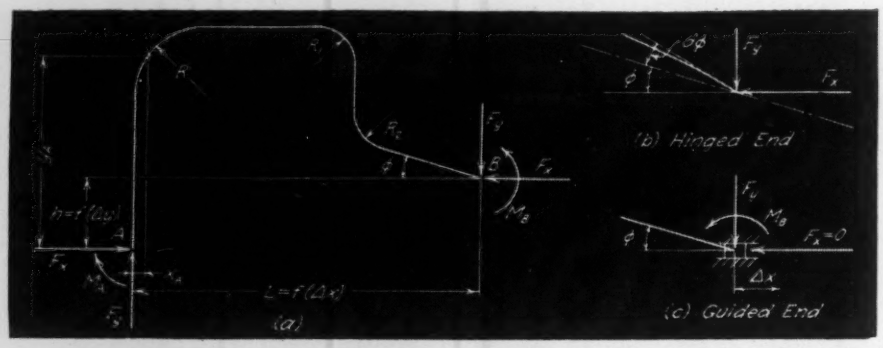


Fig. 1—(a) Bend lying in a plane and having two points of anchorage. (b) If one end is permitted to rotate freely, moment at that end is zero, and angular deviation occurs as shown here. (c) By allowing guided displacement in the direction of expansion with restraining moment M_B as shown here, the force in that direction is zero

Professor Cross. The analogies may be deduced as follows. The $y_A\ dsK/EI$, and $x_A\ dsK/EI$ may be interpreted as elementary lengths ds multiplied by K/EI. These quantities multiplied by y_A or x_A may be viewed as statical moments about point A. It is possible to select another point in such a manner that these integrals can become zero. Equations 8, 9, and 10 will then be simplified as follows:

$$\Delta x = F_x \int \frac{y^2 dsK}{EI} - F_y \int \frac{xy dsK}{EI} \quad \text{.....[11]}$$

$$\Delta y = F_x \int \frac{xy dsK}{EI} + F_y \int \frac{x^2 dsK}{EI} \quad \text{.....[12]}$$

$$0 = M_A \int \frac{dsK}{EI} \quad \text{.....[13]}$$

In the above equations, the variables x and y are without subscripts. This indicates that the integrals are to be evaluated relative to the neutral point. Solving equations 11 and 12 simultaneously for F_x and F_y and rearranging terms:

Equations 14 and 15 represent general solutions for any plane bend with two anchor points, at which points no rotation is permissible; that is, the angular change to the elastic curve is zero.

The various integrals represent certain mathematical properties associated with mechanics and strength of materials. Thus, the integrals containing x^2 and y^2 may be viewed as moments of inertias about axes passing through the centroids of the segments. Hence:

$$\left.\begin{aligned} \int y^2 \frac{dsK}{EI} &= I_{xx} \\ \int x^2 \frac{dsK}{EI} &= I_{yy} \\ \int xy \frac{dsK}{EI} &= I_{xy} \end{aligned}\right\} \quad \text{.....[16]}$$

The first two terms represent the well known properties of inertia about two rectangular axes; the third is a special quantity defined as the product of inertia. Equations 14 and 15 may be simplified, b the substitution of these quantitie :

$$\left.\begin{aligned} F_x &= \frac{\Delta x + \Delta y \dfrac{I_{xy}}{I_{yy}}}{I_{xx} - I_{xy}\dfrac{I_{xy}}{I_{yy}}} \\ F_y &= \frac{\Delta y + \Delta x \dfrac{I_{xy}}{I_{xx}}}{I_{yy} - I_{xy}\dfrac{I_{xy}}{I_{xx}}} \end{aligned}\right\} \quad \text{.....[17]}$$

These equations represent integrated forms of equations 14 and 15. To compute moments at fixed ends, infinitely rigid arms are assumed to be attached to both ends of the bend, the forces acting at the center of gravity. Moments so computed must be reversed in sign to preserve statical equilibrium.

In the column analogy concept consider the elastic line of the bend to have an elastic thickness equal to K/EI. Then the term Kds/EI represents an elastic area. Assign to this area any elementary height of unity. This will then represent an elastic column. To support such a column, an elastic medium is required. This is shown in Fig. 2.

Now Δx represents horizontal expansion of the bend in the direction of X-X axis. This horizontal expansion, $\Delta x = \int MdsKy/EI = \theta$. This expression may be visualized as rotation of deflection about X-X axis. Thus $\Delta x = M_{xx}$. Similarly $\Delta y = \int MdsKx/EI = \theta_x$; which may be viewed as rotation of Δy about Y-Y axis.

Making these substitutions, equations for F_x and F_y appear as follows:

$$\left.\begin{aligned} F_x &= \frac{M_{xx} + M_{yy}\dfrac{I_{xy}}{I_{xx}}}{I_{xx} - I_{xy}\dfrac{I_{xy}}{I_{yy}}} \\ F_y &= \frac{M_{yy} + M_{xx}\dfrac{I_{xy}}{I_{yy}}}{I_{yy} - I_{xy}\dfrac{I_{xy}}{I_{yy}}} \end{aligned}\right\} \quad \text{.....[18]}$$

Assuming the bend to rest on an elastic foundation, and deflections as moments about the two axes then there is an exact mathematical analogy between the forces acting in the pipe bend due to expan-

sions, and bending of any unsymmetrical section under the action of moments along the two axes. This is the "beam analogy", or the special solution of column analogy.

When symmetry exists, the products of inertia are zero, and the equations are simplified to:

$$F_x = \frac{M_{xx}}{I_{xx}} \text{ and } F_y = \frac{M_{yy}}{I_{yy}} \quad \ldots\ldots [19]$$

Equations 19 are identical with the simple flexure formula, $f = M/I$, in which f is the unit stress at a distance of unity from the neutral axis. Hence the determination of reactions in a plane pipe bend is analogous mathematically to the evaluations of unit stresses in flexural members. Hence the concept of beam analogy.

Procedure for Planer Two Anchored Pipe Bend

The solution of any two anchored type of pipe bend may be broken down into the following procedure:

1) Assume the bend to have variable thicknesses depending on the elastic properties of the bend, and assume the bend as supported on an elastic medium.

2) Compute centers of gravity, and moments of inertias relative to the neutral point.

3) Using the net horizontal and vertical displacements, evaluate the direct forces acting at the anchors.

4) Compute restraining moments at the anchor points, with their signs changed.

As in the majority of elastic problems, considerable time may be saved through proper tabular methods of computation. Such computations should be performed as mechanically as possible. Through tabular arrangement, adjustments of pipe bends to new dimensions may readily be made as corrections to original computations. Variations in moments of inertia of the pipe, due to different sizes or weights, and changes in modulus of elasticity with temperature enter as corrections to final values of E and I.

The presentation has so far dealt with the solution of a bend fixed at two points. Column analogy may readily be applied to a bend in which full rotation is permitted at one or at both ends. A similar procedure as outlined above will be followed, although proof of the statements will not be made.

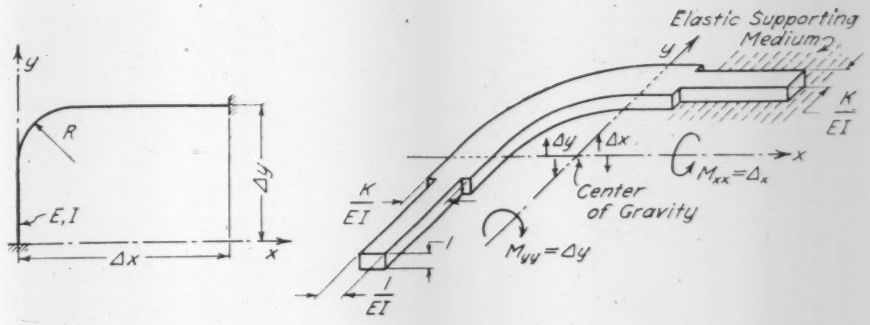


Fig. 2—For illustrating column analogy, this sketch shows the physical structure at left, and the equivalent column analogy structure at right

For a bend having complete rotation at one end, column analogy requires that moments of inertias be computed about that end. The equations previously developed apply directly. When both ends are assumed as having complete rotation, the computations are made relative to an axis passing through the end points. Again the equations as developed are applicable.

Establishing Sign Conventions

Sign conventions may readily be established from consideration of the following two cases. The first case assumes that the anchor points do not translate or rotate; that is, they are fixed. This condition is the one more often met in practice. The displacements in the X and Y directions are functions of length. Since the anchor points are stationary, direct forces must be acting in directions opposite to displacements. Moment computations follow automatically to satisfy statics.

In the second case, the anchor points may move through a distance greater than the expansion of the line. This condition arises when the vessel and the line attached to it expand differentially. Since the anchor points are pulling on the line, the direction of the forces must be in the direction of the pull. Moments must follow automatically to satisfy statics.

Limitation of Analogies

The analogies—either the elastic point or the column analogy—are applicable to conditions of full fixation or of zero restraint. When situations develop where it is possible to predict not only the linear displacement but also the angular rotation of the anchor points, quicker solutions may be obtained through the use of equations 8, 9, and 10.

It is possible for the anchor point to rotate in the direction of the tangent, or it may rotate in the opposite direction. For the first case, angular deviation would be positive, and negative for the second. The results of the second case may give results greater than for conditions of full fixation, while those of the first case less. Such conditions must be recognized in advance of actual analysis.

Multiple Plane Pipe Bends

Pipe bends lying in space and having two anchor points, ends of the pipe either fully restrained or allowed to rotate, may readily be evaluated by column analogy. A tri-plane system of notations must be used, the projections of the pipe bend in the respective planes noted, and torsional elements of the bend given due considerations in evaluating the various elastic properties. Similar reasoning as for the plane bend will lead to three equations containing direct forces acting in the direction of the three axes.

It is possible to determine general equations for evaluation of direct forces in a manner similar to the plane pipe bends. Such equations have been developed, but they are too complicated for practical use.

Effect of Pre-Strain

Pre-strain or "cold-spring" of piping is highly desirable and should be used to its fullest extent, especially for high temperature and pressure lines. Complete pre-strain minimizes creep as a consequence of expansion, reduces maintenance of equipment, alleviates local corrosion and erosion zones as a result of stress concentration, and hence

lengthens the useful life of equipment, pipe, and segmental ells.

Arguments against pre-strain are that it is lost after the line is in service, the difficulty of providing final closure because of construction inaccuracies, and finally that pre-strain delays construction.

By taking all factors into account and by providing for the effects of all forces, pre-strain will always re-appear when lines are cold. In those instances where loss of pre-strain was observed, investigations generally revealed omission of some important factor in design. When lines are investigated for all conditions, the lines installed as designed, and mechanical equipment properly positioned, there should be no reason for the pre-strain to disappear.

Final field closures may readily be made with slight difficulty by providing loose pieces for final field matching. It would appear that if the line is important enough to warrant close analytical investigations it should warrant also field matching. Using past experience on complete pre-strains of ducts varying in diameters from 30 to 48 in., pre-strain of nominal sized process and steam piping should offer little difficulty. Such pre-strain would generally result in more satisfactory pipe bends.

Column Analogy a Convenient Tool

Column analogy may be visualized as a convenient tool, since it simplifies piping analyses into an easily remembered procedure. By means of this analogy, reactions due to changes in lengths of the bend are obtained very readily. As a tool the analogy is not any more illuminating than the algebraic solution, but it does perform certain operations very quickly. It is necessary to interpret final results in terms of bending moments and reactions.

The usefulness of the analogy is not limited to the determination of reactions in pipe bends. The application of column analogy to the evaluation of bend stiffnesses, carryover factors, and moments due to displacements presents a field for future research in multi-fixed bends, either plane or in space.

Column analogy when combined with moment distribution offers considerable possibilities for evaluating simpler and more direct methods of analyses of the more complicated piping systems. At present it is possible to solve special types of plane and space piping systems utilizing both methods in a matter of minutes instead of hours.

Textile Mills Should Control Both Temperature and Humidity

Close temperature control as well as humidity control is of great importance at the Carter Fabrics Corp. for the following reasons: Textile machines (like all other machinery) are, of course, affected by any appreciable change, particularly where looms are considered and in connection with the close setting of certain loom parts. The primary effect of temperature changes in textiles that are served by central station air conditioning lies in the fact that when a temperature change occurs the central station is not always capable of maintaining constant relative humidity under fluctuation and we have the problem of a 1 deg difference or change in dry bulb temperature immediately raising or lowering the relative humidity approximately 3 percent for each degree of temperature change.

Another factor is one which is not apparent to the majority of mill men, and that is the fact that, although a constant relative humidity be held in an area and dry bulb changes occur, the moisture content of the air in the area changes according to the dry bulb temperature, although the relative humidity might remain constant. For instance, if we were running 85 F dry bulb temperature and 77 F wet bulb temperature, we would have a relative humidity of 70 percent and a moisture of 127 grains per lb of dry air; whereas, if we continue 70 percent relative humidity and drop our temperature to 80 F, we will have only 107.5 grains of moisture per lb of dry air.

The accompanying tabulation, which has been formulated from a standard psychrometric chart, shows the moisture content differential at various temperatures and relative humidities. This differential does not, of course, affect the constant RH, but does serve as a means to show the wide differential in moisture content of the air at various temperatures.

Further, the pliability of the size coating is in direct relation to the temperature as well as the RH; therefore, to have the work run consistently the temperature should be consistent.

We consider the temperature control as being of equal importance to the control of relative humidity for the above reasons.—G. F. Benn, superintendent of maintenance, Carter Fabrics Corp., weavers of rayon fabrics, Greensboro, N. C.

Moisture content of air (in grains per pound of air) at various dry bulbs, wet bulbs, and relative humidities

	60% RH		65% RH		70% RH		75% RH	
Dry Bulb, F	Moisture Content	Wet Bulb, F	Moisture Content	Wet Bulb, F	Moisture Content	Wet Bulb, F	Moisture Content	Wet Bulb, F
65	55.0	56.7	59.5	57.5	64.5	59.9	69.0	60.0
70	65.5	61.0	70.6	62.0	76.6	63.5	82.0	64.5
75	78.0	65.3	84.0	66.5	91.0	68.0	97.0	69.0
80	92.0	69.6	99.5	71.0	107.5	72.5	115.0	73.6
85	108.0	74.0	117.5	75.5	127.0	77.0	135.0	78.2

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SELECTING CHILLED WATER COILS

J. A. BISHOP, district manager, American Blower Corp., Dallas, considers the problem of selection of chilled water coils for air conditioning from the viewpoint of the engineer. There is no straightforward procedure, he says, that can be used to set up the components of coil duty and at the same time will assure the coil's matching the duty. Certain assumptions are necessary, and the purpose of this article is to provide some general guiding values

MUCH OF THE published information on chilled water coils for air conditioning applications is so set up as to facilitate the selection of coils to meet as nearly as possible a specified duty in which quantity and temperature of water, entering and leaving air conditions, cfm, and velocity are given. Such an approach views the problem of the engineer who must set these values in retrospect. Is it any wonder then that we all too frequently see coil specifications that no coil can possibly fulfil?

Our aim here is to view the problem from the standpoint of the engineer. Unfortunately, there is no straightforward procedure that the engineer can use to set up these components of the coil duty and at the same time be sure that the coil characteristics match the duty. But fortunately, it is possible to set these values to correspond reasonably well with coil characteristics, provided we make certain assumptions that—even if slightly in error—do not make too much difference in the final result. However, the engineer should have some general values in his mind so that his initial assumptions will be sufficiently close and thus eliminate long and tedious trial and error computations before arriving at a satisfactory balance. It is the purpose of this article to provide such general guiding values for the required assumptions.

Let us limit our consideration to the changes that occur to a unit weight of air from the time it enters the coil to the time it leaves the conditioned space, and let us further consider that condition only wherein all heat quantities remain constant. In other words, we will exclude any consideration of control to meet varying loads but we will consider the selection of coils to meet different load conditions. The various loads are assumed to be the result of calculations at design conditions. Let us further limit our consideration to the usual and more typical problems and disregard special cases such as those in which the sensible heat is extremely low or where conditions to be maintained are unusual, as in process work. In other words, let's consider only the common garden variety of problems.

Coil Doesn't Know the Method Used

There have been many times when engineers have indicated that they have trouble with water coil selection because of the different methods used, and there is always the implication that the different methods yield different results. But the fundamental laws of heat transfer are the same for all, and the thermodynamic properties of air and vapor mixtures are constant; furthermore, the coil that finally goes on the job doesn't know which procedure was used in its selection. There is, of course, some difference in efficiency of heat transfer so that one make of coil might require five rows and another make six rows for the same duty; but if a coil of a given face area is furnished with a certain quantity of chilled water at a certain temperature, the slope of the cooling line will be about the same regardless of the coil used, generally speaking.

Let us start with an internal load of one ton or 12,000 Btu, of which 85 percent is sensible. The internal design conditions are 80 F DB, 67 F WB. The outside design is 100 F DB and 78 F WB, with 25 percent outside air. Then let us look at the same problem with all conditions unchanged except that the internal sensible heat ratio is changed from 85 percent to 70 percent.

For the first part of this problem, let us take the psychrometric chart of Fig. 1. Point 1 is the room condition, and point 2 is the temperature to which the supply air must be cooled, if saturated, to satisfy the internal load conditions. This temperature is 58.4 F. Now refer to Fig. 2; if the internal ratio is 70 percent, this same point 2 is 53.6 F. It might be well to point out that for a given problem the quantity of air required, based on a saturated condition of that air, is the least quantity that can possibly be used to accomplish the desired results. In our two cases, the air required with 85 percent sensible heat is 435 cfm and with 70 percent sensible heat is 293 cfm, assuming that the air is saturated.

It is well recognized that the air leaving coils is never saturated (in this case we are not considering

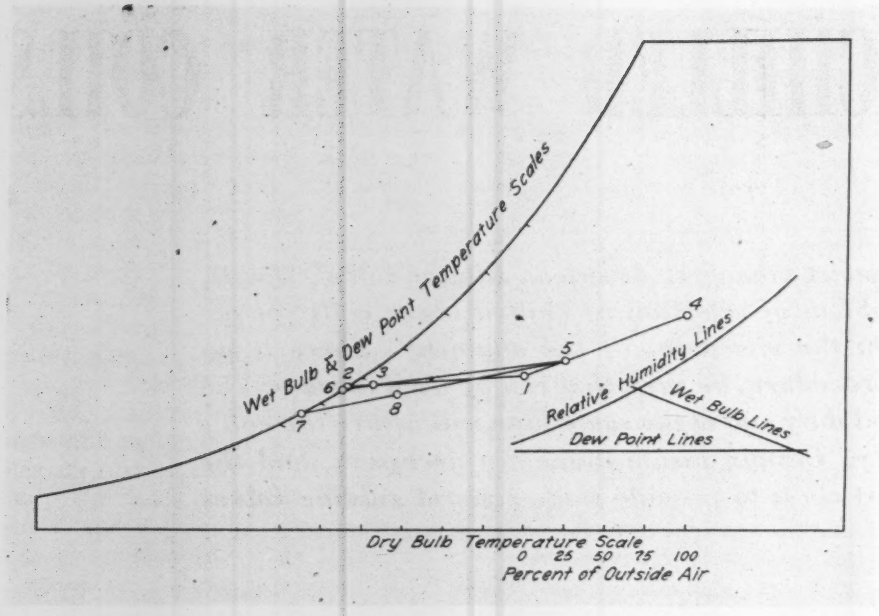


Fig. 1—Skeleton psychrometric chart showing the points plotted for the example given in the text. In this problem, the ratio of the internal sensible heat to the internal total heat is 85 percent

sprayed coils). The approach to saturation varies directly with the depth of the coil, inversely with the spread between the initial dry bulb and dew point, and inversely with the velocity. Since velocity is limited on the downward side by the economics of the matter, and since carryover of water limits the velocity on the upward side to about 475 fpm, this variable for practical purposes becomes a constant. Also, in the normal job with outside air percentages of from 20 to 50 percent, the spread between entering dry bulb and entering dew point does not vary enough to make any practical difference. Hence, the approach toward saturation for practical purposes has only one variable, namely, the depth of coil; assuming, of course, that the load is within the capacity of the coil and that dehumidifying is taking place.

Divergence in Selection Methods

It is at this point that there is a divergence in the various methods of coil selection. One widely used procedure makes use of what is called surface temperature. This surface temperature lies on the saturation curve midway between the entering water temperature and the leaving wet bulb. A line drawn from this point to a point representing the condition of the air entering the coil is the line along which the air is cooled in passing through the coil. The difficulty with this procedure is that it presupposes a determination of the air quantity and the entering water temperature. Yet, if these two values are not properly selected, no coil can be selected that will balance out with the required ratio of sensible to total heat.

Another method is to assume a leaving relative humidity for a given depth of coil in rows. A variation of this method that is a little easier to work with, and possibly a little more accurate, is to correlate the DB—DP of the leaving air with the initial DB—DP times a factor for depth of coil in rows. The important point to remember here is that entering water temperature and air quantity come after this determination and not before; otherwise, the package is not tied up but falls apart. Furthermore, the surface temperature method ties in with this, as will be evident later.

Now let us look at the magnitude of variation that can occur between the limits set by our two problems. The entering DB—DP for both problems is the same, 85—63 or 22 F. The multipliers for depth of coil vary from 0.252 for four row and 0.125 for six row to 0.063 for eight row. Thus, we have a final DB—DP of 5.5, 2.75, and 1.38 F. These values, if taken in connection with lines 1-2 on the psychrometric chart, correspond to relative humidities in the order of 82, 91, and 96 percent respectively. These values are approximate only and would vary slightly with the change in saturated temperature required by the change in sensible heat ratio. They do, however, give a general idea as to how the percentage of saturation of air leaving a coil may vary with the depth of the coil. They also show that there is a correlation of method, whether percentage of saturation is assumed or whether the variation of that method, using initial dry bulb minus dew point times the coil depth factor, is used.

Next, let us draw a line on each of the charts representing the change in the condition of the air as it picks up the room load. In the case of Fig. 1, this line runs from 58.4 F saturated to the room condition of 80 F DB and 67 F WB, and in Fig. 2 it runs from 53.6 F saturated to 80 F DB and 67 F WB. The slope of these lines represents the ratio of room sensible heat to room total heat. This ratio should not be confused with the ratio of sensible to total heat for the coil.

We are now faced with the necessity of making an intelligent guess as to the number of rows required in our coil; but, fortunately, a sizable error here will be less serious to the performance of the job than to blindly assume some air quantity or some desired leaving dry bulb and some water temperature that may not come within a mile of matching the coil performance. Say that we assume a six row coil for both our problems. Then our leaving air conditions are, for Fig. 1, 58.7 F DP, 61.4 F DB, 59.7 F WB, and the cfm required is 505. For Fig. 2, our leaving air conditions are 54.75 F DP, 57.5 F DB, 55.8 F WB, and the cfm required is 344. These points are shown on the charts as point 3.

What the Coil Must Do

We are now ready to consider the problem from the point of view of what the coil must do. For this purpose we must have the condition of the air entering the coil. Point 4 is the outside design condition of 100 F DB and 78 F WB and is the same for both charts. We can draw a line connecting points 1 and 4, and this line will represent the conditions of a mixture of outside and recirculated air.

If on the dry bulb scale we add an auxiliary scale between 80 F and 100 F and assign values on this scale from 0 to 100 percent, we can read directly on the line connecting points 1 and 4, the conditions of the air entering the coil corresponding to any percentage of outside air. With 25 percent outside air, the air entering the coil in both problems is at 85 F DB, 70 F WB, and 63 F DP. This is point 5 on each chart.

It is now desirable to return to the concept of surface temperature. A line connecting points 3 and 5 and continued on to meet the saturation curve will give us the surface temperature required for the duty. This surface temperature is point 6. In the case of Fig. 1, surface temperature is 57.8 F, and in the case of Fig. 2, surface temperature is 52.6 F. We can now determine the entering water temperature, since $T_w = 2T_s - WB_r$; where T_w is entering water temperature, T_s is surface temperature, and WB_r is the wet bulb of the air leaving the coil. In our problems the entering water temperature for Fig. 1 is 55.9 F and for Fig. 2 is 49.4 F.

We are now ready to consider the actual coil selection. Here again we have a divergence of method, depending on whether the transfer coefficient is based on total heat with a factor of less than one, or is based on sensible heat with a factor greater than one. In either case, the factor varies with the ratio of sensible to total heat. This is of no consequence for it comes to the same thing. In this solution we will use a total heat coefficient, and an air velocity through the coil of 475 fpm. We will further assume a water velocity of 4.5 fps and a 10 F water rise.

To determine the coil load, we now consider points 5 and 3, and the slope of the line connecting them is the ratio of sensible to total heat for the coil. Please note that this is not the same as the slope of line 1 to 2, which is the ratio of sensible to total heat of the room load only.

In Fig. 1, the coil total heat is that required to cool 505 cfm from 70 F wet bulb to 59.7 F wet bulb, or 17,520 Btu. The coil sensible heat is that required to cool 505 cfm from 85 F dry bulb to 61.4 F dry bulb, or 12,930 Btu. In this case the coil ratio of sensible to total heat is 73.8 percent. The minimum coil face area is determined by dividing 505 cfm by 475 fpm velocity, and results in a required coil face area of 1.063 sq ft.

In Fig. 2, the coil total heat is that required to cool 344 cfm from 70 F wet bulb to 55.8 F wet bulb, or 15,790 Btu. The coil sensible heat is that required to cool 344 cfm from 85 F dry bulb to 57.5 F dry bulb, or 10,270 Btu. In this case the coil ratio of sensible to total heat is 65 percent. The minimum coil face area is determined by dividing 344 cfm by 475 fpm velocity, and results in a required coil face area of 0.725 sq ft.

Now, using the data of a prominent coil manufacturer, we find that the transfer coefficient for the coil of Fig. 1, with an air velocity of 475 fpm and a water velocity of 4.5 fps, when corrected for the ratio of sensible to total heat of 73.8 percent, is 218 Btu per sq ft of face area, per degree mean effective difference (MED), per row deep.

We also find for the coil of Fig. 2, with the same air and water velocities, but corrected for a ratio of sensible to total heat of 65 percent, that the transfer coefficient is 238 Btu per sq ft of face area, per degree MED, per row deep.

The MED for Fig. 1 is:

Air	61.4	←	85.0
Water	55.9	→	65.9
	5.5		19.1 or 10.9 MED

The MED for Fig. 2 is:

Air	57.5	←	85.0
Water	49.4	→	59.4
	8.1		25.6 or 15.2 MED

We then have the following solutions:

$$\text{Fig. 1: } \frac{17520}{218 \times 1.063 \times 10.9} = 6.94 \text{ rows}$$

$$\text{Fig. 2: } \frac{15790}{238 \times 0.725 \times 15.2} = 6.02 \text{ rows}$$

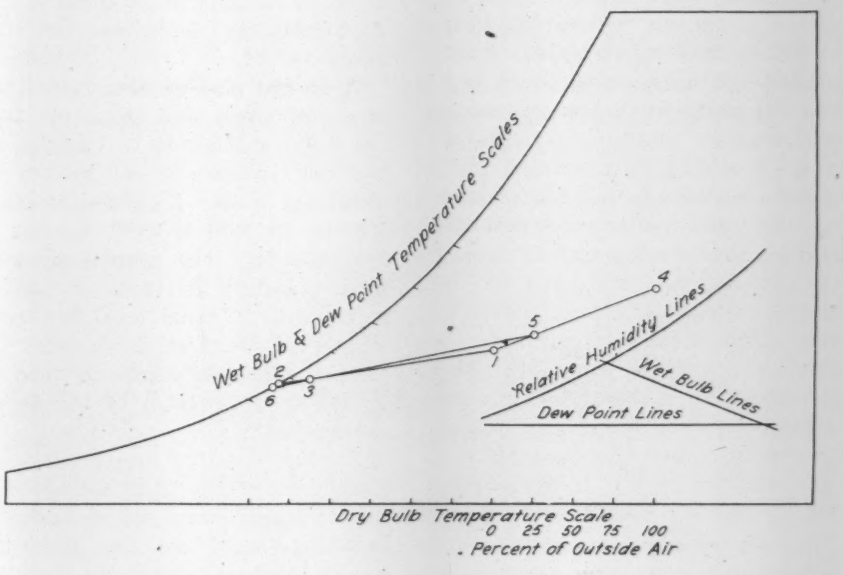
These solutions show that the higher the ratio of internal or room sensible heat to internal or room total heat, the higher must be the initial water temperature, the greater must be the quantity of air handled by the coil, and, consequently, the greater must be the coil face area and also the greater must be the depth of the coil.

Since the coil for Fig. 1 requires seven rows, and our original assumption of six rows was used to estimate the approach to saturation of our leaving air, our solution is not exactly accurate. However, it is close enough for all practical purposes and very much more accurate than if we had used 60 F DB for the air leaving the coil and had picked some initial water temperature out of the blue and then tried to make a coil match up.

Water Temperature Can't Be Picked Blindly

It might be well to investigate what occurs when a water temperature is selected without regard to

Fig. 2—This skeleton psychrometric chart is similar to that of Fig. 1, except that in this case the internal sensible heat ratio is 70 percent instead of 85 percent



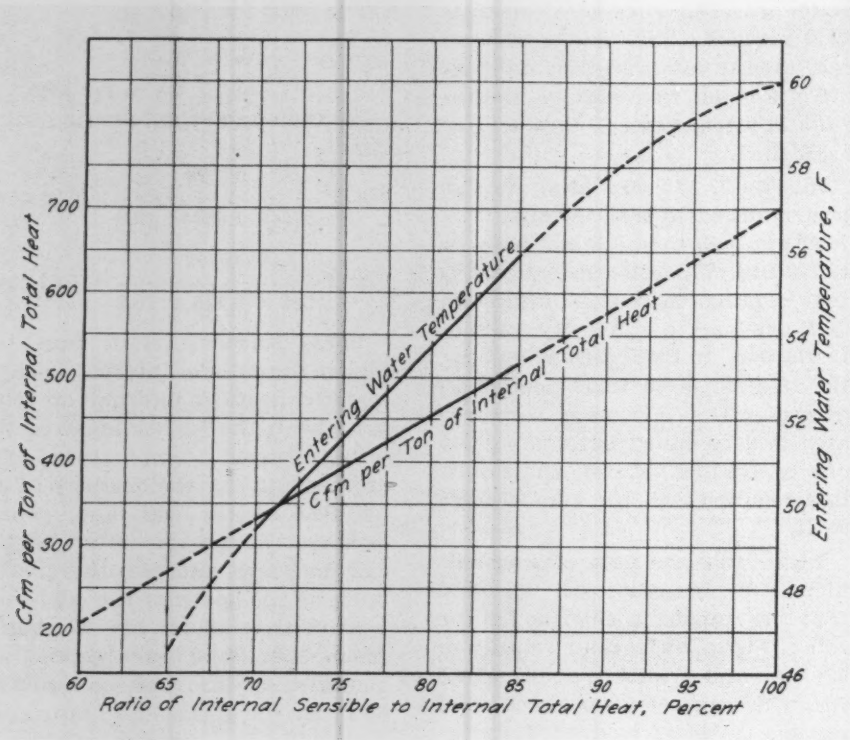


Fig. 3—Curves prepared by the author for the approximate selection of entering water temperature and cfm when correlated to usual coil performance

ratio of sensible to total heat. Suppose we select 46 F water with an 8 F rise, as is often done, and try to select a coil for Fig. 1. First, we will determine the surface temperature and find that it is 52.8 F; we will call it point 7. Then line 5 to 7 crosses the leaving wet bulb line of 59.7 F at 64.3 F. This is point 8, and we see that it is not on the room load line 1—2; so it cannot satisfy these load conditions. The coil will be short on sensible cooling and will result in a higher dry bulb in the room than we want. On the other hand, if we select the coil big enough to handle the sensible heat, we will be over-coiled on total heat, possibly as much as 20 to 30 percent. If we have that much excess refrigeration capacity available, lower humidity is produced than called for. This is not too serious, but the customer has bought and paid for excess refrigeration capacity and has an expensive job to operate. If, as is usually the case, there is no excess refrigeration, the water temperature will rise in the system. Because the system is then under-coiled for the higher water temperature, the relative humidity rises, and we have a muggy condition in the air conditioned space.

But let us proceed with the selection of a coil. The solution is the same as before except that the MED changes from 10.9 to 22.7.

$$\text{Fig. 1: } \frac{17520}{218 \times 1.063 \times 22.7} = 3.33 \text{ rows}$$

It now becomes readily apparent that the selection of a water temperature by the engineer without correlating it with coil performance rating and room ratio of sensible to total heat permits the furnishing of too shallow a coil. This results in a lower coil price but in a higher overall cost, a higher operating cost, a job of insufficient flexibility, and, all too frequently, an unsatisfactory condition in the space served.

It should also be clear from the study of these two problems that the volume of air to be handled by the coil cannot be set by simply assuming a dry bulb temperature leaving the coil of 60 F. Rather, it is a fact that the volume of air is determined by the ratio of internal sensible to internal total heat and degree of saturation of the air leaving the coil which, in turn, is primarily a function of the depth of the coil.

Throughout this presentation we have apparently been solving two separate problems, but we can now combine them. We then have the range required for a single installation as the internal ratio changes from 85 percent to 70 percent, with the total internal load remaining constant and the outside air conditions being constant. Since the internal load is on the unit basis of one ton, any change in internal total load is a multiple of these results. The range is only approximate for an actual job due to the fact that outside air conditions would no doubt vary with changes in internal ratio; in fact, the ratio change would be induced by the outside changes. But the introduction of still another variable would too greatly complicate the problem for the purposes of this presentation.

Our purpose has been to show, in a general way, how the various parts of this problem fit together and to develop some approximate values rather than to present a theoretical analysis. Extreme accuracy has been sacrificed in order to present a practical and not too time-consuming solution of these problems. Thus, calculations were made on a cfm basis—whereas pounds should have been used for extreme accuracy.

In converting degrees change in dry bulb per cfm to Btu per hr, a factor of 1.085 has been used, and for converting differences in total heat per pound into Btu per hr, cfm times 4.45 has been used. It may, however, be worthwhile to know that with ratios of internal to total heat ranging from 85 percent down to 70 percent, the cfm per ton of internal total heat should range approximately from 500 cfm to 350 cfm, the initial water temperature should at the same time vary from 56 F to 49 F, and then the coil depth will vary from seven to six rows with the deeper coil being required where the sensible to total ratio is highest.

Approximate Selection of Cfm. Water Temperature

Referring to Fig. 3, which gives curves for approximate selection of cfm and entering water temperature, some further conclusions can be drawn from this study. But first it should be pointed out that to determine many points for these curves would require much tedious calculation and for our purposes such accuracy is hardly necessary. We know that for the middle range of from 70 percent to 85 percent

ratio that these curves are approximately straight lines and they have been so drawn. In the range above and below 70 percent to 85 percent, the cfm curve will still be approximately a straight line but the water temperature will take a form similar to the dotted portion of the curve.

If it is understood that the cfm as thus determined is the cfm that must pass through the coil in order to satisfy the internal load conditions and is not necessarily the air quantity that the fan is to handle, the value of a coil bypass becomes apparent under changing load conditions. Thus if the air quantity, based on a ratio of 85 percent, is 515 cfm per ton of internal load, so far as fan capacity is concerned, and the internal ratio drops to 70 percent due to a change in occupancy or lower outside temperature or a change in sun exposure, the quantity of air through the coil per ton of internal load must drop to 334 cfm. The difference should be bypassed if a change in the air distribution pattern is to be avoided. The amount of bypass would be further accentuated under these conditions by a probable simultaneous drop in total load for the air conditioned space.

It can further be seen that the cfm referred to throughout this discussion is the cfm through the coil and the leaving air temperatures are those of the air leaving the coil. This does not prevent the engineer from using a larger cfm if necessary to obtain satisfactory distribution or to obtain a higher air temperature entering the conditioned space provided the additional air figured for either or both of these purposes is recirculated from the conditioned space and bypassed around the coil.

It will be further seen that if control of room conditions is to be accomplished a change in water temperature must also occur. This could be done by a three-way mixing valve at the circulating pump and on multiple unit jobs accurate control would require a separate pump and mixing valve for each unit.

How Coil Selection Affects Operation

The maximum load on the refrigerating machine will occur with maximum ratio of sensible to total heat and at this point maximum water temperature is also required. Thus, at this point maximum MED in the water cooler exists, making possible the use of smaller coolers and the operation of the refrigeration machine at higher suction temperatures where better efficiency is available. At lighter loads, corresponding to lower sensible to total ratios, the refrigerating machine and water cooler will be able to produce the lower water temperature required. It should, however, be understood that these advantages can only be had if the coil selection has been based on the maximum load at the maximum ratio and with the water temperature corresponding to these values. Such selection results in a deeper and somewhat more expensive coil and greater fan capacity, but the small increase in cost is more than offset by lower cost of the refrigerating equipment and lower operating costs.

A partial exception to the above reasoning on cost is the case where in a multiple unit job the refrigeration machine must produce minimum water temperature because of low sensible to total heat ratio in the case of part of the units. But even here a considerable saving occurs for the reason that if the coils are selected on the low water temperature those units operating on high ratios of sensible to total heat will, in order to do the required sensible heat cooling, require refrigeration capacity greatly in excess of that actually required had the greater coil capacity been provided and a higher water temperature supplied to those units.

Snow Melting System Shown in Action

What happens when an under-the-sidewalk snow melting system undertakes to clear a 4 in. snowfall is shown in these pictures. Fig. 1 illustrates how the melting proceeds as hot water, with antifreeze added, flows through pipe embedded in the concrete walk. Note there is no runoff of water. The snow melts and water quickly evaporates.

Fig. 2 was taken 40 min later. All snow has disappeared and the sidewalk is virtually free of moisture.

These pictures were taken at the Protane Gas Service Co., Erie, Pa., a subsidiary of the Protane Corp., retailers of LP gas and LP stoves, refrigerators, and other appliances.

The sidewalk equipped with the system is 12 ft wide and 51 ft long. The system consists of a gas water heater and lengths of 1 in. wrought iron pipe spaced a foot apart.

Fig. 1—How melting proceeds with under-the-sidewalk system with a 4 in. snowfall

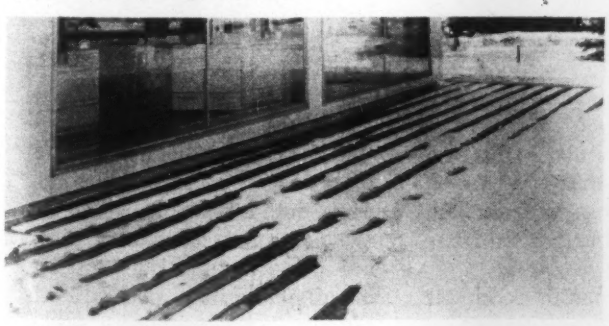
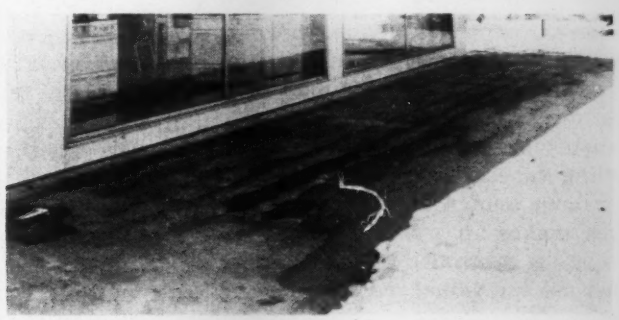


Fig. 2—Forty minutes later, the snow has disappeared and the walk is virtually free of moisture



The occupant of the stateroom selects his own weather by setting the room thermostat

Individual Control for AIR CONDITIONED SHIP

INDIVIDUALLY controlled air conditioned comfort from bow to stern highlights the modern luxurious facilities of Matson Navigation Co.'s new S. S. Lurline, recently placed in service between San Francisco and Hawaii. Each of the 500-odd staterooms is equipped with individual, automatic temperature controls; the occupant selects his own weather merely by setting the thermostat in his room. Crew quarters, dining rooms, lounges and other public areas, as well as provision storage rooms, are also air conditioned.

Divided Into 32 Zones

According to J. A. Cutler, president of Johnson Service Co., the staterooms and other occupied areas of the ship are divided into 32 zones. Each zone is supplied with outdoor air from one of 32 central fan systems. In general, the staterooms are divided into zones according to exposure, while each dining room, lounge, and other public area makes up a zone in itself. Each zone is controlled in the same manner as individual rooms.

The 32 central fan systems take in outdoor air and, depending upon the outdoor temperature, heat or cool it to about 50 F. The cooling process also reduces the relative humidity of the air. The central fan systems are completely and individually controlled so that outdoor air of the proper amount and of the correct temperature and moisture content can be supplied to each zone regardless of the requirements of the other zones.

Each stateroom is equipped with a small air conditioning unit located in the ceiling space above the washroom. Preconditioned air from the central fan systems is supplied to these units through concealed duct work. Each room unit has a grille through which air is discharged into the stateroom, and another grille, behind which a heating coil is located, to permit air from the stateroom to return to the unit. Preconditioned outdoor air from a central fan enters the room unit, induces a flow of air from the room through the return grille and heating coil, after which it is mixed with the incoming outdoor air and the mixture is discharged into the room.

About three volumes of room air are recirculated for each volume of preconditioned outdoor air supplied to the unit, the outdoor air being cold enough to supply all of the cooling needed on the warmest day. Hot water is supplied to the heating coil, in the path of the return air, under control of a room thermostat operating a water valve. Whenever all of the cooling is not required, this thermostat causes heat to be added to the return air, thus raising the temperature of the mixture before it is delivered into the room.

AIR POLLUTION IS MORE THAN SMOKE

"More and more people are beginning to understand the magnitude of abating air pollution," H. B. Lammers, chairman of the Coal Producers Committee for Smoke Abatement told the members of the executive committee of the organization at a recent meeting.

"Where previously the burning of fuel, and more especially coal, was blamed for most of the pollution over our cities, informed persons are beginning to realize that there are other things polluting the atmosphere besides products of combustion," Mr. Lammers said.

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How to Figure Pipe Length Between Two Elbows

A READER HAS asked how to figure the length of a piece of pipe between two 45 deg elbows, and if it is the same for all sizes of pipe. He asks also if there is a book or publication giving information on "measuring pipes."

A formula for computing the length of a piece of pipe between two standard elbows was developed and copyrighted in 1932. It comprises a scroll shaped scale that can be read easily down to eighths of an inch. The length of the offset piece of pipe as read from the scale, however, must be corrected by reference to the accompanying table, because the length of a standard thread varies with the diameter of the pipe. Thus, if dimension *A* is 2 ft, the length of *B* of the angular pipe would be 2 ft, 9⅞ in., less ⅞ in. if the diameter of the pipe is 1 in. and less 1⅞ in. if the diameter of the pipe is 2 in.

Another scheme, which may or may not seem simpler, is to compute the length of the angular pipe:

L = length end to end of the angular pipe.

A = offset distance.

C = distance from edge of fitting to threaded end of pipe (thread engagement).

B = distance from center of fitting to edge of fitting.

k = 1.41 for 45 deg offsets.

k = 2.0 for 30 deg offsets when *A* is shorter distance.

Then $L = (A \times k) - 2 \times (B - C)$

Using the above example,

A = 24 in.

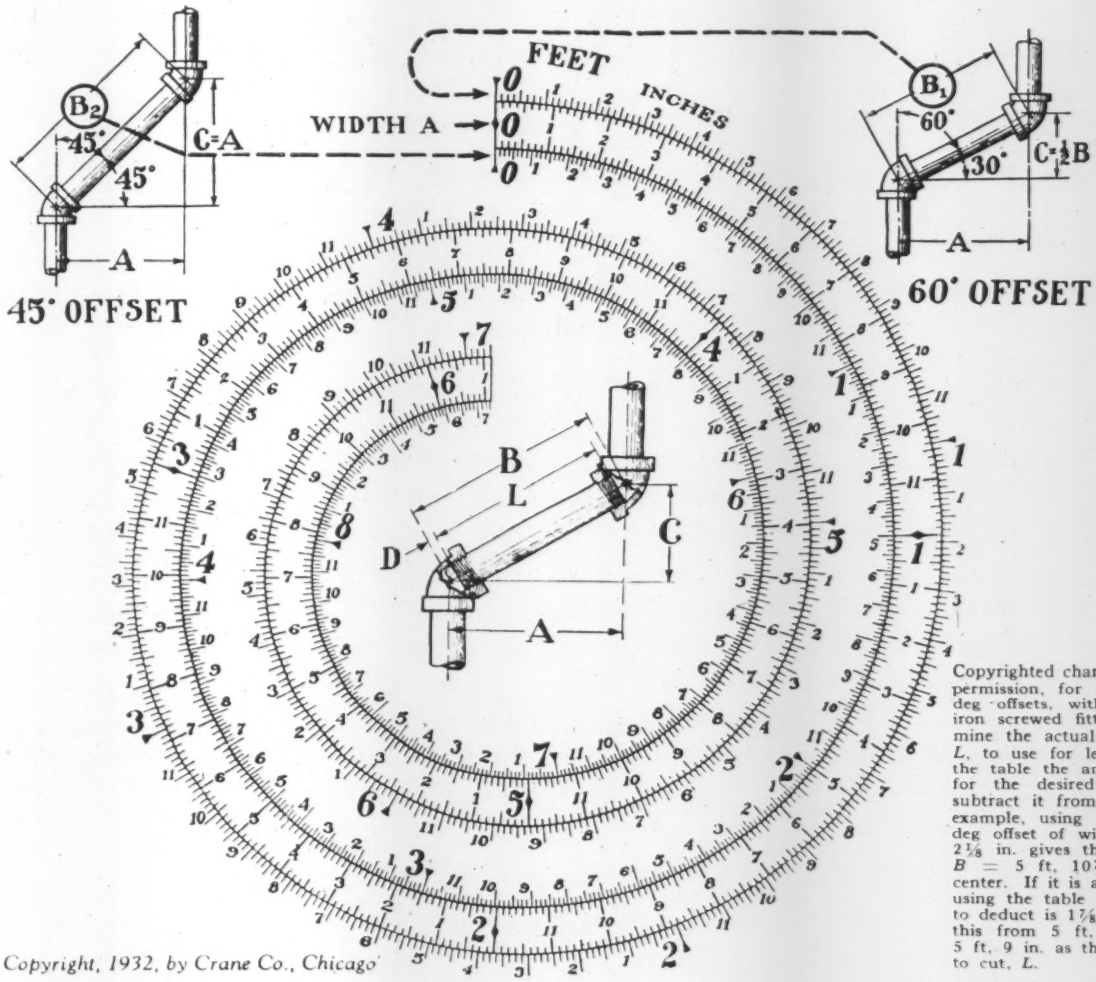
B = 1.562 in. for 2 in. diameter standard malleable iron 45 deg fitting.

C = 0.75 in. for 2 in. diameter.

Then (24 × 1.41) — 2 (1.562 — 0.75) = 32.2 in., or 2 ft, 8⅛+ in., which is near enough to the result by the chart to be inconsequential.

—SAMUEL R. LEWIS, consulting engineer, member, HPAC's board of consulting and contributing editors.

Reading to ⅛ Inches



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Copyrighted chart, reproduced by permission, for 45 deg and 60 deg offsets, with standard cast iron screwed fittings. To determine the actual length of pipe, *L*, to use for length *B*, find in the table the amount to deduct for the desired pipe size and subtract it from length *B*. For example, using the chart a 45 deg offset of width *A* = 4 ft, 2⅛ in. gives the length of run *B* = 5 ft, 10⅞ in. center to center. If it is a 2 in. pipe then using the table find the amount to deduct is 1⅞ in. Subtracting this from 5 ft, 10⅞ in. gives 5 ft, 9 in. as the length of pipe to cut, *L*.

Pipe size	Inches	¼	⅜	½	¾	1	1¼	1½	2	2½
45° deduct	Inches	¾	⅞	¾	⅞	⅞	1¼	1½	1⅞	2
60° deduct	Inches			1	1	1⅛	1½	1⅞	2¼	2½

Pipe size	Inches	3	3½	4	5	6	8	10	12
45° deduct	Inches	2⅜	2⅝	3	3⅝	4¼	5⅝	7⅛	8½
60° deduct	Inches	3		3¾	4½	5½	9⅛	9⅛	

Note—The above figures represent 2x*D*. To find *D* divide by 2.

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135 Practical Pointers on VALVE MAINTENANCE

GEORGE HOLMAN, operating engineer, draws on his years of personal experience to list these suggestions on when a valve needs service, the symptoms of various troubles, what to do about them, and what to watch out for when installing valves

PIPE LINE VALVES may be classified by:

1) Design (gate, globe, check, piston, butterfly, etc.).

2) Line fluid (steam, ammonia, carbon dioxide, etc.).

3) Type of service (throttling, reducing, blowdown, relief).

4) Special design features (screw and yoke, double gate, etc.).

5) Special trim (renewable seats, composition disk, etc.).

6) Method of pipe connection (flange ends, threaded ends).

7) Method of operating (manual, automatic, quick opening).

8) Metal it is made of (brass, steel, malleable iron).

9) Safe working pressure (300 lb, 600 lb, etc.).

10) Particular service (bypass valve, drain valve, etc.).

Valves are also classified in other ways. If the functions they fill in service are examined, however, most pipe line valves fall into one of three great families: (1) stop valves; (2) intermittently acting valves; and (3) throttling, or regulating valves.

Stop valves, of which the common gate and globe valves are examples, are usually hand operated, and remain either open or closed for long periods. Except for needle valves, such as some used as hand expansion valves in refrigeration service, regulating valves are usually automatic in operation. The diaphragm motor valve is the type form of this family. The intermittently operating valve is a stop valve which is either completely open or completely closed, the opening and closing at short intervals being regulated by an automatic device. The bucket operated steam trap is an outstanding type of this third family of valves.

When a Valve Needs Service

In practice, a stop valve requires service when

A) It leaks at the seat.

B) It leaks through the packing.

C) It leaks at threads, flange gaskets, or bonnet.

D) It does not open to permit flow, even if the spindle turns.

E) It does not close to stop flow, even if spindle turns.

F) It is noisy in service.

A) If a valve leaks at the seat:

1) The valve (that is, gate or disk) or seat, or both, has been cut by erosion. Reseat or replace.

2) The valve or seat has been pitted by corrosion. Reseat, regrind, or replace.

3) Scale or other foreign matter has gotten between the valve and seat. Clean out.

4) The valve or seat has been warped by impact, pressure, or high temperature. Replace.

5) The valve or seat has been roughened by chatter. Reseat, regrind, or replace.

6) Scale has formed on the valve

and/or seat during long open period. Clean and regrind.

7) Groove has been formed on valve or seat by closing valve against foreign body. Grind out, recut, or replace.

8) Composition valve ring is too hard. Replace with softer one.

9) Valve or composition ring is cracked. Replace.

10) Soft composition ring is impregnated with grit. Replace.

11) Disk of globe valve locked on spindle out of line with the seat. Adjust valve properly.

12) Pieces of composition ring stuck to seat. Clean seat and replace ring.

13) Disk has come off spindle. Adjust and repair.

14) New seat and/or new valve do not match. Replace one or both.

15) Seat ring pressed or screwed into valve body has come loose. Refit or renew seat ring.

16) Worn collar on spindle fails to spread double gates amply. Replace spindle or valve, or both.

17) Spreader pin of double gate valve lost or badly worn. Replace pin, and possibly gates also.

18) Faces of solid wedge gate not at same angle as seat rings. Replace gate or rings.

19) Seat ground too wide, requiring excessive pressure on valve wheel to seal. Replace valve or seat ring.

20) Valve body warped by impact, high temperature, or high pressure. Replace entire valve.

21) Hole has been eroded or corroded in globe valve web. Replace entire valve.

22) Globe valve web has been cracked. Replace entire valve.

23) Warped cylinder guides throw valve out of line with seat. Change guides, or replace valve.

24) Too tight packing on spindle prevents firm seating of valve. Repack.

25) Galled spindle threads seize and prevent firm seating of valve. Replace spindle, or entire bonnet assembly.

26) Threaded part of spindle twisted, and prevents valve seating firmly. Replace spindle or entire bonnet assembly.

27) Pieces of packing get into spindle threads, and prevent firm seating of valve. Clean out spindle threads and stuffing box, and repack stem with proper packing.

B) If a valve leaks through the stem packing:

1) The packing has become hard. Repack.

2) The gland has been taken up fully. Repack. Do not fill in new packing on top of the old.

3) The spindle requires lubrication.

4) Wrong kind of packing is being used. Repack.

5) The spindle has been scored, as by packing hook. Replace.

6) The spindle has been pitted by corrosion. Replace.

7) The spindle has been worn tapered. Replace.

8) The spindle has been bent. Straighten or replace.

9) Gaps in rings of split packing have not been staggered around the stem. Repack properly.

10) Paint or caked oil on spindle disturbs packing when valve is closed. Clean stem.

11) Packing nut tightens on threads; packing remains loose in stuffing box. Clean threads. Refit nut on threads properly.

12) Packing gland binds against stuffing box or spindle, and does not compress packing. Be sure gland fits stuffing box.

C) If leaks occur in valve body, at flange gaskets, bonnet, or threaded ends:

1) Erosion or corrosion has cut through the valve body. Replace.

2) Gasket has lost its resiliency. Renew gasket.

3) Gasket has been torn. Replace.

4) Old gasket was not thoroughly scraped off before inserting new gasket. Clean flange surfaces and replace gasket.

5) Gasket is of wrong material. Use correct gasket material for replacement.

6) Gasket too thick. Use thinner material.

7) Stud or bolt nuts unevenly taken up. Tighten nuts evenly.

8) Stud or bolt nuts binding on threads and do not exert pressure on gasket. Run tap through nuts and die over studs and bolts.

9) Flange surfaces warped. Replace valve or reface flanges in lathe.

10) Flange surfaces pitted by corrosion. Reface flanges.

11) Cracks or sandholes in flange surfaces. Replace valve.

12) Valve not screwed on pipe to full threads. Screw valve on farther. If necessary, recut threads.

13) Threaded end of valve out of round. Run tap into threaded end. In extreme case, discard entire valve.

14) Threads cut with dull or misset dies. Thread pipe ends properly with sharp dies.

15) Pipe threads are cut too deep. Valve tightens against a shoulder. Recut pipe threads properly.

16) Threaded end of pipe has corroded. Replace pipe.

17) No lubricant used when making iron or steel valve assembly on pipe. Use white or red lead, or other suitable lubricant.

18) Piping is installed in strain, with prying strain on valve threads or flange. Line up piping system properly.

19) Pipe is broken off inside valve end. Replace pipe after ascertaining cause of break.

D) If the valve does not open to permit flow, even if spindle turns:

1) Valve (disk or gate) has seized the seat.

2) Solid wedge gate has wedged against the seat rings.

3) Foreign body has lodged above the gate or disk.

4) Grit, rust, or scale acts as a binding agent in seizure of valve on seat.

5) Worn spindle collar has permitted spindle to rise out of gate or disk.

6) Galled spindle threads cause spindle to bind.

7) Spindle is broken off inside valve.

8) Foreign matter, such as packing, gets into spindle threads, and prevents turning.

9) Worn spindle collar wedges between bosses, and causes binding of double gate valves.

E) If the valve does not close to stop the flow:

1) Valve has come off the spindle collar.

2) Foreign body between valve and seat.

3) Galled spindle threads prevent closing valve tightly.

4) Spindle is broken off.

5) Body of valve is warped.

6) Web of globe valve may be corroded through.

F) If the valve slams, chatters, whistles, or hums in service:

1) Any gate valve partly open to throttle flow may become noisy.

2) Any free-seating globe valve may become noisy when nearly closed to throttle flow.

3) Spindle is too free.

4) Spindle collar is badly worn.

5) Nut is loose on disk assembly.

Keep These Points in Mind

When installing or servicing stop valves, keep in mind the following pointers:

Installation

1) A new valve should screw on a newly cut pipe not more than a "turn and a half" freehand. If the valve can be screwed on three or more turns before using a wrench, the pipe threads are undercut, and the joint may leak. Or, the pipe end may abut against the web of a globe valve, or against the underside of a seat ring of a gate valve. Distortion due to pressure against the pipe end may cause the valve to leak, or otherwise fail to function properly.

2) Ream all pipe ends before cutting the threads. Otherwise the reamer, especially if dull, may expand the pipe at the end, thereby giving the threads the wrong taper. A joint made up with male and female threads of different tapers must be excessively tight to hold.

3) Bronze valves and steel or iron pipe are compatible, and therefore need no lubricant on the threads when a joint is made.

4) Always use the end of the wrench on the end of the valve being screwed on the pipe. If the wrench must be used on the other end, first screw a nipple into that end for backing. This will keep the twisting pressure of the wrench from distorting the valve threads, and leaving the bore out of round. Test for roundness of the bore may be made with nipple threads coated lightly with prussian blue.

5) When cutting pipe threads with other than solid block dies, be sure all cutters are firm in the head. A loose cutter will shave the threads. These threads will make a poor joint with the full size threads of all standard pipe fittings.

6) When welding a pipe at or near a valve, a wet cloth laid on the bonnet or wrapped about the valve is insurance against distortion and leakage at the threads.

7) When screwing a flange onto a pipe, a buggy bar purchased on bolts through the flange holes is often a better tool than standard wrenches.

8) Before installing any valve, be sure the pressure it is built to work under, generally stamped on the body, is higher than the highest pressure that can exist in the piping system.

9) Be sure any new valve is suitable to the system fluid. A composition disk may be suitable for low pressure steam, yet soften if used for superheated steam.

10) In all cases where a valve is installed at the end of a pipe line containing a dangerous fluid under pressure, as steam, ammonia, etc., the open end of the valve should be plugged when not in use.

11) Where pressure drop in a pipe line must be avoided, place a valve as far away from other fittings as is consistent with utility and design.

12) Choice of a stop valve depends upon operating procedure. A gate valve is proper where pressure drop is to be avoided. A globe valve is proper for throttling flow.

13) If a globe valve is installed to close against the direction of flow, it can be packed simply by closing, if no pressure exists on the downstream side.

14) Even if the pipe line is to be completely covered with insulation, paint the threads adjacent to the valve, as a precaution against corrosion.

15) When installing flange end valves, use spud wrenches and drift pins sparingly. The better practice is to align the piping system RIGHT. If two pipes are out of line, the best of joints connecting them may fail.

16) If opening or closing a valve without proper system preparation is dangerous, remove the wheel of such valve, or lock it in such manner that unauthorized use of the valve is impossible.

17) If possible, all valves of a piping system should be opened and closed periodically, as insurance that they will function properly when necessary.

Packing

18) Stem packing of small valves should never be so tight that both hands or a wrench is necessary to turn the spindle.

19) If a piping system contains some valves which can be packed under pressure, while others must be shut off, each type should have distinctive markings on valve body or wheel.

20) When repacking small valves, a small wheel puller is an asset.

21) Choice of stem packing is important. Be sure that the packing being used is suitable for the job.

22) If packing has hardened in the stuffing box, removing it by probing with a hook may be time-consuming, and may also damage the spindle. The better procedure is to pull the wheel and draw out the spindle. No matter how hard it is, the packing may then be easily removed, and the stuffing box cleaned thoroughly.

23) Unless the necessity of getting a valve back into immediate service demands haste, the bottom rings of old packing should never be left in the stuffing box merely because they are hard to get out.

24) Never paint that part of the spindle of a rising stem valve that feeds down into the stuffing box. The paint will only rub off with usage, and may cause the packing to leak.

25) Use a blunt piece of hard fiber or wood to push the packing into the stuffing box.

26) No matter if flow past a closed gate valve has completely ceased, maximum pressure against the bonnet will remain if the upstream side of the gate leaks, even though the downstream side seats perfectly. Under these conditions, attempting to repack the spindle would be dangerous.

27) Valve stem packing punched from sheet material may be used in three ways: (a) uncut, in which the wheel must be taken off to get it over the spindle; (b) straight cut, in which the cut is parallel to the spindle; and (c) angular cut, in which the cut is approximately 45 deg to the spindle. The first is best, although sometimes not practical. Straight cut packing fills the stuffing box under pressure more evenly than angular cut.

28) Before attempting to pack the stem of an ammonia valve under pressure, locate the isolating valves and make sure they are in working order. The valve may not backseat perfectly. When the packing nut is removed, ammonia pres-

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ure may blow out the packing. Or, a strong leak may develop, requiring isolation of the valve for repacking.

29) String packing may be wound around the stem and pressed into the stuffing box. But spiral packing should be cut into rings, and each ring separately pressed into the stuffing box before the following rings are inserted.

30) A corkscrew packing hook made of spring steel wire is often a handy tool to fish out old packing. A ¼ in. carpenter's wood bit and brace will help loosen up packing in larger valves. Flute edges of the drill bit should be ground off to prevent scoring of the valve spindle.

Gaskets

31) Flange and bonnet gasket material should be of uniform thickness and as thin as possible. Check uniformity with micrometers.

32) When opening a piping system at flanges or valve bonnet, always leave the nuts on two opposite bolts or studs until the flange surfaces have been separated. Should the isolating valves leak, or in case of failure to close them, high pressure may exist in the system. Most industrial fluids blowing out between flanges can inflict serious injury. If the two bolts are left in place, and the nuts loosened slightly, any developing blow can be kept under control, and the flanges quickly recoupled.

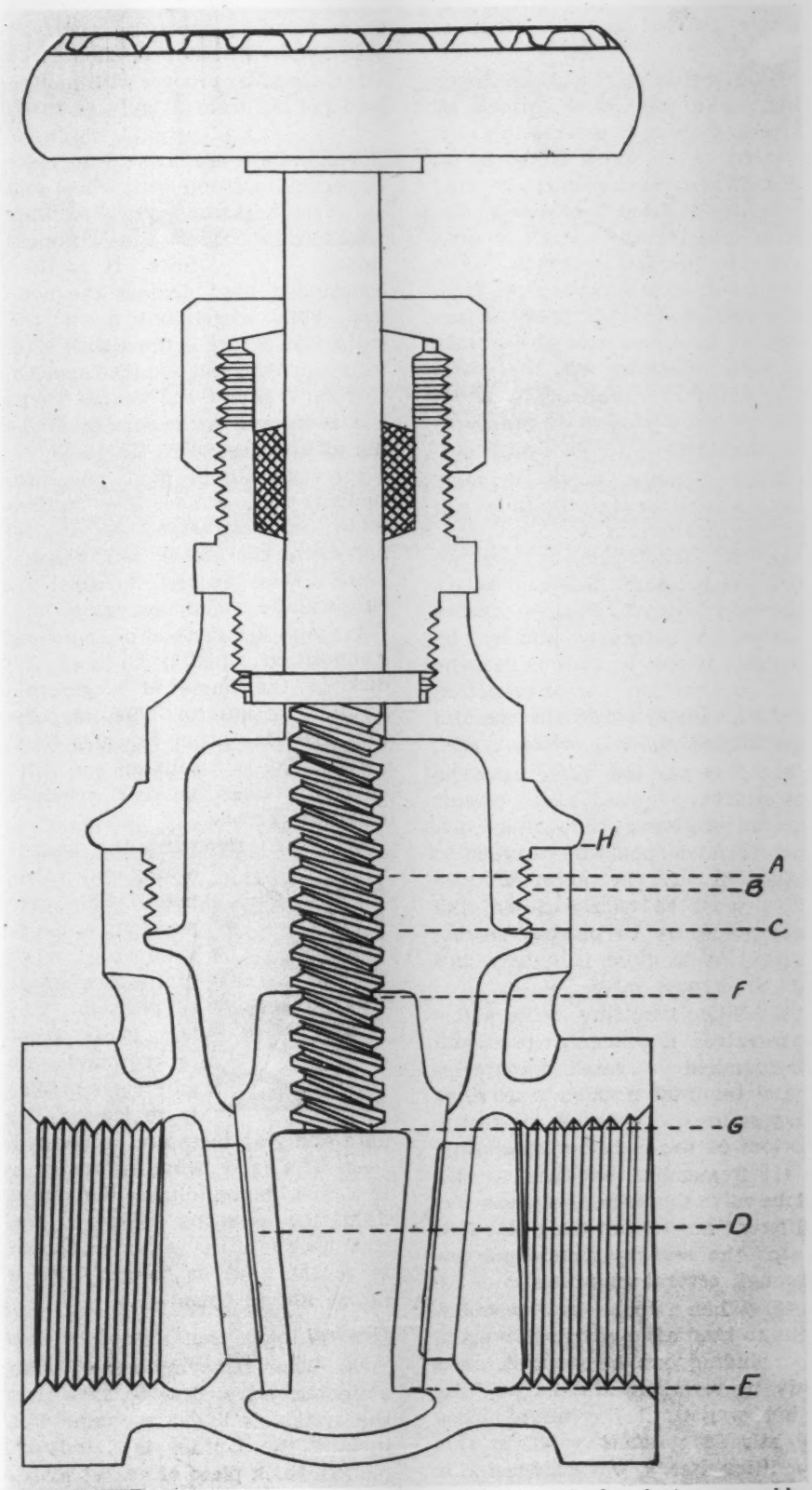
33) A gasoline torch is a useful tool for quickly removing old pieces of gasket from flanges.

34) Large gaskets of thin material may be cut accurately enough on the face with a ballpeen hammer. Small gaskets and/or thick material do not lend themselves readily to this technique.

Seats

35) Sometimes an old valve can be reseated more quickly than a new one can be installed. Even though a seat is "removable," it may stick and require cutting out. If a reseater is available, the better practice may be to recut the seat in place than to take time out for complete replacement.

36) If the wrench lugs have been broken or corroded off the inside of screwed-in seat rings, come-alongs may be used to remove the rings. These may be made of a flat piece



How threads are stripped on spindle of nonrising stem valve during assembly. While bonnet being screwed on moves from A to B, the gate moves from A to C. Since five turns are required to seal the bonnet, it is apparent that the gate cannot move five times the distance from A to C before it jams against its seat. If the lower end of the gate is at D when screwing the bonnet is started, enormous strain may be placed on the spindle threads between F and G in attempting to seat the bonnet at H. Ignorant or thoughtless pipefitters often damage or strip the threads, sometimes in the gate nut, but more often on the end of the spindle. The only precautionary measure necessary is to make two or three opening turns of the spindle while the bonnet is being turned on

of steel twisted to form left-hand flutes.

37) If a gate valve has stood open long, scale may have formed on valve and seats. When closing such a valve, never screw it tightly at once. When pressure must be used to tighten it, back it off one or two turns, and try again until it seats firmly to the feel or touch. As it closes, the valve scrapes scale from gate and seat. Full pressure applied at once may scar the seating surfaces. Backing off the valve gives the fluid a chance to wash off this loose scale before it can damage the seats.

38) A common cause of valve leakage at the seat is the failure of the operator to seat the valve properly; that is, firmly but with no excessive pressure. In steam valves especially, slight leakage causes "cutting" of both valve and seat by particles of rust or scale in suspension, and by the corrosive action of chemically active substances, and some normal solids in solution.

39) If a throttle valve must be set so nearly closed as to permit wiredrawing across the seat, a much smaller valve should be installed to bypass it. If the main throttle valve must be nearly closed, the best procedure to prevent steam-cutting is to close it tightly and use the bypass valve.

40) When recutting solid wedge gate valves, new seat rings should be installed. A small amount of metal removed from gate or rings may cause the wedge to strike the bottom of the body before closing.

41) Remember that the seat of a globe valve should be at a somewhat different angle than the disk. This keeps the seating surface narrow through several grindings.

42) When a double gate valve begins to bind after starting to open, the binding can be stopped, as a rule, by reversing and turning the other way until the valve moves slightly to close. A valve in this condition has a worn stem collar which spreads the gates hard against their seats as it tries to pull out of the gate recesses provided for it.

43) When repairing valves, a pail of gasoline and a jug of acid solvent should be kept handy, the former for removing oil or grease and the latter for scale deposits.

44) Some ammonia valves may be reseated by replacing the lead seat rings. Another method is to fill the annular grooves with molten lead poured from a ladle or fused with a blowpipe, using a small tip. The spindle is set on an iron plate in vertical position with wheel end up. The backseat groove is filled with lead, cooled and trimmed smooth with a knife. It is then backseated hard against the bonnet. With wheel end down, the main seat groove is filled with lead, cooled quickly, and trimmed smooth. If done expertly, the bonnet keeps the backseat from melting by drawing off the heat.

45) Composition disk rings are seldom easy to remove. One method is to cut a crosswise vee to the bottom of the groove with a small chisel. Once broken through, the ring usually comes out easily.

46) Another method of removing composition rings is to hold the disk in the flame of a gasoline torch for a minute. The composition material either becomes fluid, catches fire, or swells up and softens until it can be easily removed from the groove.

47) When removing the bonnet of any gate valve, mark each gate position, and reassemble with each gate in proper position. Unless it is recut or reground, any gate valve is likely to leak if the gate and seat faces are exchanged.

48) If a valve being worked on is in a pipe line handling a dangerous fluid, the isolating valves, if not within sight of the workmen, should be locked shut or flagged with a notice not to open.

General

49) When removing bonnet of an ammonia valve, first be sure that the system is under vacuum. The instant the bonnet is lifted off, place a thick piece of gasket material or diaphragm rubber over the valve body. Atmospheric pressure will hold the gasket against the vacuum in the pipes. This prevents early feedback of residue ammonia fumes. Inrush of air when the seal is removed carries the fumes away from the workmen, and gives them time to seal the valve with the bonnet.

50) If any large pipe line is frequently shut down for long periods, all horizontal valves should be fitted with plugs or petcocks so that the bowls may be drained. Brass trim is attacked by corrosive fluids, such as condensate, standing for long periods in a valve.

51) If a steam valve remains closed for a time, a common test for leakage is to feel the pipe downstream from the valve. If the pipe remains hot beyond the usual conductivity range, the valve is leaking.

52) When removing a valve bonnet, remember that sticking gaskets have been known to hold a bonnet against several pounds pressure after all bolts have been removed.

53) When assembling a screw bonnet, nonrising stem gate valve, be sure that the gate is well up in the bonnet at the start. For rapid opening and closing, many gate valves have double or triple threads on the spindle. For each full turn of the bonnet, the gate may move a quarter inch or more. If half closed when the bonnet is started on, the gate may jam against the seats before the bonnet seats. The spindle threads may be stripped.

54) A weakness of the nonrising stem valve is that sludge gets into the threads easily.

55) In the rising stem valve, most lost motion due to wear is at the stem collar and the mating boss on the gate or disk. In the nonrising stem valve, lost motion due to wear is usually at the threads, and is never so pronounced.

56) When opening or closing a long unused valve, the operator should be prepared to cope with leakage of the stem packing.

57) When listened to with a stethescope, or with a stick between the teeth and hands over ears, leakage of steam through a valve badly steam cut has a whistling or sonorous sound. If the valve is only slightly cut, however, leakage is identified by subdued gurgling, or sometimes by weakly popping sounds. If a leak is strong, steam is blowing from high pressure into steam at lower pressure; if the leak is weak, steam is blowing into comparatively cool air or condensing in condensate.

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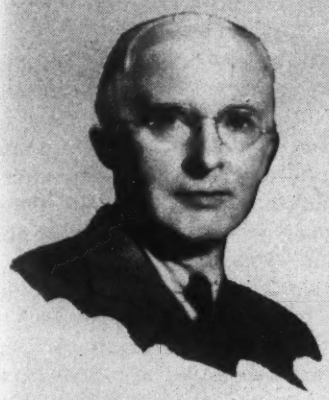


SAM LEWIS' PAGE

Informal comment on heating, piping, and air conditioning matters is given in this regular feature by Samuel R. Lewis, consulting mechanical engineer, member HPAC's board of consulting and contributing editors

Combining Two Steam Plants Cuts the Cost

Two heads are better than one, the saying goes, but in the particular case analyzed here for neighboring factories, the cost of 1000 lb of steam will apparently be lower if their steam generation is combined in one plant. Reduction in heat losses by eliminating a separate boiler house, economies in labor, and reduced maintenance and supplies are the reasons

THERE IS NOT an over-abundance of information available as to operating costs for large steam heating plants. As of 1948, any cost data available indicate considerably higher prices than were in effect before the war (as is the case with about everything else).

I had occasion recently to review the investment and operating costs of some school heating systems that I tabulated in 1932. The result of this review compelled me to convert the 1932 dollars back to pounds of coal and gallons of oil, which—like acres of land—do not fluctuate so wildly. (Traditionally thrifty people like the French are said to hold to the land as the only stable medium of exchange in times of inflation.)

The purpose of my review was to enable me to advise two large corporations, who are friendly neighbors to each other, whether they should combine their steam production or should operate separate plants.

Corporation "A" has an immediate demand for 40,000 lb per hr of steam. A new boiler plant is contemplated. Corporation "B" has a present demand for 60,000 lb per hr of steam, supplied from its existing very modern boiler plant.

The plant at "A," not yet built, was designed to include three water tube boilers fired by spreader stokers and to operate at 100 psi. It has mechanical coal handling from railway or truck to the stoker hoppers, but does not employ air preheaters, steam superheaters, economizers, or other accessories designed to help in gaining the last hard-to-get increments of efficiency. The assumed efficiency therefore was 70 percent.

The plant at "B" includes a single 60,000 lb boiler and furnace, operating at 400 psi pressure, and the boiler is fitted out with elaborate auxiliaries predicated on routine delivery of steam at never less than 80 percent efficiency.

Coal of 10,500 Btu per lb costs $6.50 per ton, carload delivery, to either plant.

Under the present conditions, if the "A" plant were in being, it would produce per season 116,000,000 lb of steam while the "B" plant would need 105,000,000 lb of steam. The relatively simple boilers, stokers, coal conveyor, and building for "A" will cost $350,000. The boiler plant building, boilers, accessories, etc., at "B" have cost $575,000. If "A" joins "B," the additional investment to bring that plant up to 100,000 lb per hr output will be $25,000. Interest on both plants is figured at 3½ percent; depreciation at 5 percent; and taxes and insurance are lumped at 1½ percent. The plants both must operate 24 hr per day.

Labor is costing $26,000 per year at the "B" plant, including three

Basic data on the two steam plants

	"A"	"B"	"A" plus "B"
Installed capacity	40,000	60,000	100,000
Yearly production	116,000,000	105,000,000	221,000,000
Efficiency	0.70	0.80	0.80
Tons of coal required	8,000	6,200	13,000
Capital investment	$350,000	$575,000	$600,000

Cost to own and operate

10 percent of capital	$35,000	$57,500	$60,000
Cost of fuel	52,000	40,300	84,500
Labor	26,000	26,000	30,000
Ash disposal	3,500	3,000	5,000
Electric power	3,400	7,200	10,000
Miscellaneous costs	4,000	3,000	5,000
Total costs	$123,900	$137,000	$194,500
Cost per 1000 lb of steam	1.068	1.310	0.880

engineers, four firemen, a coal passer, and an electrician. If the "B" plant furnishes all the steam, the labor there increases only to $30,000.

Ash disposal is mechanical from the boilers to a storage bunker, but an allowance of $3.00 per ton of ashes for ultimate removal was necessary. The arrangements for coal and ash handling at plant "B" are more favorable than they will be at plant "A".

Power for pumps, conveyors, stokers, etc., costs $7200 for "B".

Using the foregoing information from the "B" plant experience, it was possible to construct the accompanying tabulations.

As will be seen from the costs of 1000 lb of steam given, if Father and Mother—or "A" and "B", in this case—give up their separate beds and snuggle together under the thicker covers on a cold night, they may waken refreshed in the morning even though the windows in the bedroom were opened wide.

In computing the cost per 1000 lb of steam for the combined "A" plus "B" plants, despite the higher capital investment, it appears that the larger, more efficient combined equipment (the double bed) commences to pay out by aid of the economies in labor, reduction in heat losses by elimination of a separate boiler house for plant "A" (the single beds), and by reduction in maintenance and supplies.

How to Insulate Floor Slabs

How to build a warm, dry, concrete floor for a basementless structure was told last month by the University of Illinois, Urbana. After nearly a year of research, during which nine different types of floor slabs were tested in a special laboratory, the university recommends:

1) Good drainage, with a 4 in. fill of coarse washed gravel or crushed rock under the floor slab.

2) A vapor barrier, consisting of a ⅛ in. rigid asphalt board or of reinforced duplex paper with asphalt center, over the fill and extending to the outside edge of the floor.

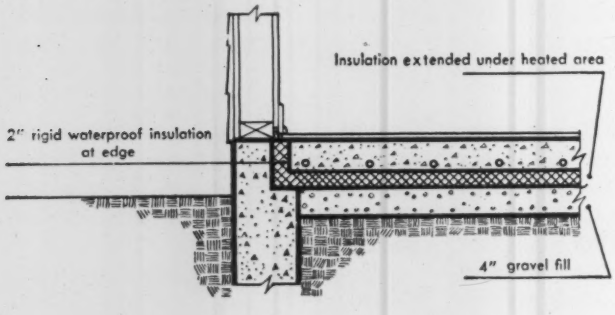
3) At least 2 in. of rigid waterproof insulation along the exposed edge of the floor and extending 2 ft under it.

The research was carried out by the small homes council and the mechanical engineering department at the university; findings are reported in a 4 page nontechnical circular titled Concrete Floors for Basementless Houses. Copies can be obtained free for a limited time. The project was under a cooperative agreement with the U. S. Department of Commerce.

Existing uninsulated floors can be made warmer by placing 2 in. rigid waterproof insulation on the outside, from floor level down to at least 12 in. in the ground. This should be firmly attached to the foundation, with flashing over the top to prevent water getting behind it, and protected by an asbestos cement board.

When panel heating systems are used with concrete floors, the heat loss to the ground and at the edge is increased due to the higher temperatures maintained in the floors according to the circular. To prevent excessive heat losses in such floors, a minimum of 2 in. of rigid waterproof insulation should be provided at the edge (see sketch). In addition, the use of insulation under the entire heated floor area is recommended. Gravel and rock fills are desirable for drainage controls, but they have no insulating value.

Insulation recommended with floor panel heating system

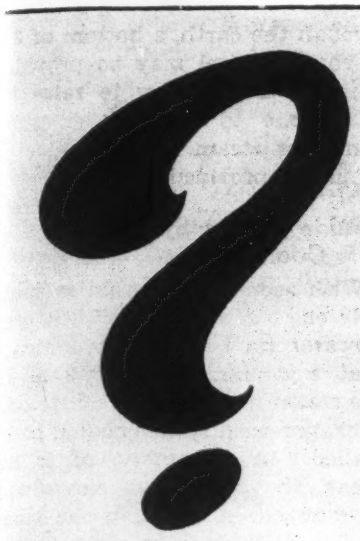


UTILITY GAS SALES CONTINUE TO GAIN

Despite shortages of steel and other materials that restrict the expansion of production and distribution facilities of the gas utility industry, total sales of gas to ultimate consumers continued to rise in June, aggregating 2,245,092,000 therms for the month, a gain of 6.4 percent compared with the like month a year earlier, the American Gas Association has reported.

For the 12 months ending June 30, 1948, total sales of gas amounted to 30,551,223,000 therms, an increase of 8.5 percent over the previous year.

The association's gas sales index on June 30 stood at 214.2 percent of the 1935-1939 average.



QUESTION OF THE MONTH

YOU ARE invited to submit a heating, piping, or air conditioning question for publication here. You are also invited to submit answers to previously-published questions from others. Those published are paid for at regular rates. Address the Editor, Heating, Piping & Air Conditioning, 6 N. Michigan Ave., Chicago 2, Ill.

What Is Best Way to Supply Steam, Electricity to College Buildings?

In the July issue, the chief engineer of a college asked for assistance in planning the steam and electrical generation and distribution to the nine buildings now on the campus, the two new buildings now under construction, and two more new ones expected in the next 12 to 18 months. The following comments from readers are in reply to his request

REFERRING TO THE question from a reader published on page 97 of the July issue, the planning of a central heating, power generation, and steam distribution system for a college or university must be thorough and far reaching. Though the cost of a complete system will be high, it is foolish to talk of the future when lower prices prevail, for when lower costs are prevalent our economy would be such that institutions requiring this type of installation would be financially unable to undertake such a project. With this in mind, I have attempted to set up a new and completely integrated central heat and power system based on the data given.

Since little information besides the base heat and electric loads of the various buildings was given in the question as published, I have set up on these data an imaginary system as shown in Fig. 1.

The first step is to decide on the electrical characteristics of the current to be provided. It was decided to generate alternating current at 2300 volts, 3 phase, 60 cycle, in view of its ease of transmission and conversion; 2300 volt generation was selected since there is the possibility of future expansion growing beyond the 2000 ft radius with the consequent excessive voltage drop. The electric generation is provided by one 750 kw, 2300 volt, 3 phase, 60 cycle turbogenerator. This unit will have a throttle pressure of 250 psig and a variable back pressure of 50 psig. During periods of low load with this arrangement, the exhaust pressure will drop to meet demand conditions of the steam system. There should be a spare 50 kw diesel or gasoline driven emergency lighting generator set. Where the state codes prescribe further auxiliary lighting in the dormitories, 10 or 15 kw automatic gasoline driven units of a type approved by the state may be provided for each building where necessary. A small motor generator set or mercury arc rectifier may be used in the laboratory buildings for furnishing direct current for experimental purposes.

Steam generation is the next step and the boilers are designed for a maximum of 250 psig with 100 F of superheat. These units will deliver steam at 250 psi to the turbine and will bleed through a reducing station into the main distribution header when there is an extremely high steam demand. In the future, when utility power may come into the scheme, the full steam pressure may then be thrown into the steam distribution system. This will result in reaching more remote areas and the carrying of higher demands more economically.

Steam Distribution Piping

The steam distribution system should be piped in an underground conduit. The system will consist of one large diameter main to branch

point "A", Fig. 1. From the branch point, a smaller diameter line should go east and another west. Both the large and the small pipe lines will be sheathed in conduit and insulated. The condensate return line paralleling the steam lines should be enclosed in a separate conduit and insulated. A typical installation is shown in Fig. 2.

Expansion loops, together with the necessary anchors, must be provided where calculations indicate they are needed. The branch lines to the various buildings should be taken off at points as close to the main line anchor points as possible, to prevent introducing main line stresses in the lines to the buildings. Where this is not feasible or where the length of the run from the main line to the buildings makes them necessary, expansion loops must be provided. Where necessary, expansion joints may be installed within the buildings.

Reducing Stations and Trapping

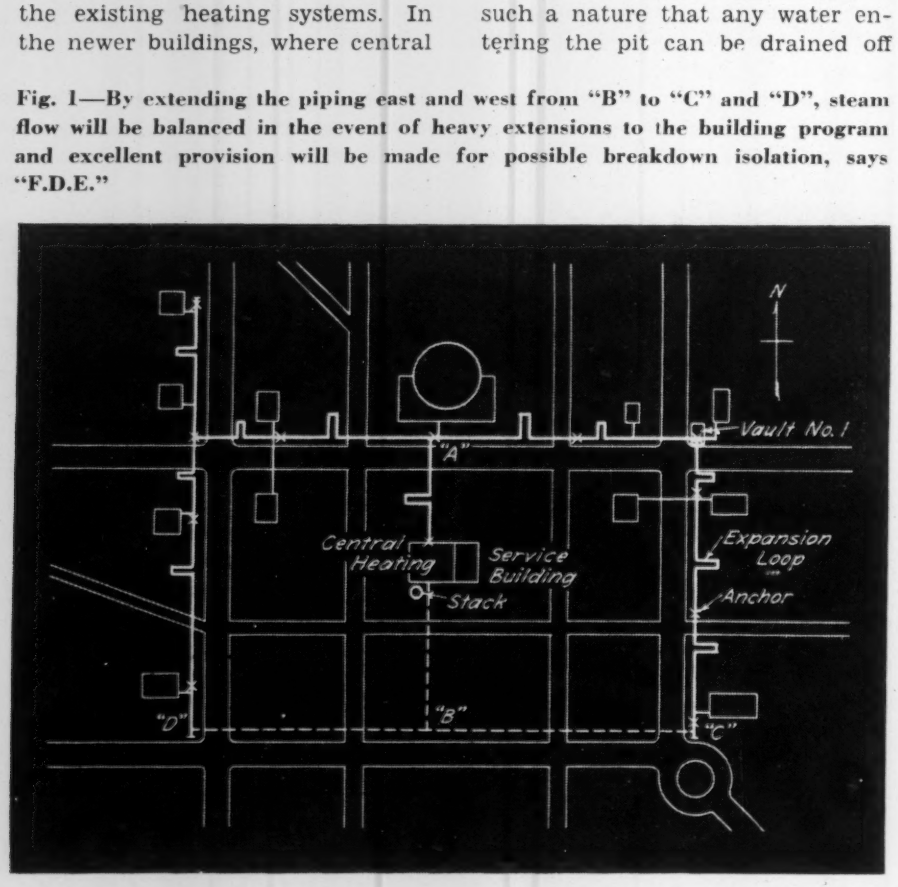
Reducing stations should be installed in all the old buildings to furnish steam at low pressure to the existing heating systems. In the newer buildings, where central warm air distribution units may be used, the steam should be available at higher pressures. The service building should include a laundry to which steam is available at 100 to 125 psi. The service building has been shown next to the central heating plant in Fig. 1 to take advantage of the short run of pipe necessary to transmit the high pressure steam.

An infirmary, the science laboratories, and possible future engineering labs may also require steam at higher pressures, and would require the installation of utility power which would free the entire steam capacity at high pressure for system distribution. The alternative to this would be a small line transmitting 250 psi steam directly to the buildings demanding high pressure.

To insure the proper drainage of condensate from low points in the lines or in the building, a double trapping system should be used as shown in Fig. 3.

Where vaults or pits are necessary for a condensate collection point, at a low spot as indicated in Fig. 1 by vault No. 1, they will be made of concrete. Where drainage is easily obtained from existing drainage systems, the pits should have concrete floors. Where the ground is of such a nature that any water entering the pit can be drained off through the earth, a bottom of 2 ft of coarse gravel may be provided. When it is necessary to raise the condensate to sewer level, sump pumps or steam actuated ejectors should be provided.

Fig. 1—By extending the piping east and west from "B" to "C" and "D", steam flow will be balanced in the event of heavy extensions to the building program and excellent provision will be made for possible breakdown isolation, says "F.D.E."



Double Header System Is Good Practice

With economical design in mind, only one steam line has been used. However, the best practice indicates that a double header system for the steam mains with a single condensate return system should be installed. In the event of a line break, the condensate can always be dumped. A break in the steam line is a much more serious problem, but a double line with its necessary sectionalizing valves, pits at every building take off, and complicated expansion problems due to the necessity of frequent anchor points to remove stress from valves and pits, would be very costly.

Using the system as shown in Fig. 1, it would be a simple matter to extend the steam main south from the central heating plant to point "B", and then run a line east and west connecting with the present lines at points "C" and "D" to form a loop system. This loop would serve to keep the flow of steam balanced in the event of high steam demand from the future possible heavy extension to the building program. Sectionalizing valves could be installed, making an excellent provision for possible breakdown isolation and accomplishing it more economically than with a double pipe system.

The electric power distribution system may be laid underground in the same trench as the steam conduits providing a wire with good insulation is used. To prevent line injury due to digging in proximity to the electric cables it would be good economy to enclose them in conduit. Transformers should be placed in each building to lower the current to normal lighting or power needs. Due to the distances involved, it would be uneconomical to transmit at less than 2300 volts.

Engage a Competent Engineer

In closing, I would like to urge strongly that a competent engineer or engineering organization be contracted for on a project of this scope. It has been my experience.

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with work of this nature, that only experienced personnel can successfully calculate, layout, design, and supervise the construction of this type of work.

However, it is my hope that these comments may give the university engineer a better conception of an up-to-date system. It should enable the reader to make an intelligent presentation to the college board and provide a background of modern practice as a basis for conversation with a qualified engineer or engineering company.—F.D.E.

MANY FACTORS AFFECT BEST WAY TO DO JOB

IN THE JULY issue of HPAC, the chief engineer of a college asked about the best way to supply steam and electricity to his buildings.

From the information supplementing this question, it is my opinion that there isn't any *best* way. More data on the plant set up will be required before very many decisions can be made.

Probably the first thing to consider is this: Is the plant isolated?

Investigate Tie-In With Utility

Most states have laws that will not permit one of their institutions to be in competition with a public utility. Now if the power plant with which we are concerned is a part of a state institution, and if the state laws are as mentioned above, then the power plant is isolated. For such a situation the plant, in my opinion, should have an installed kw capacity of approximately twice its normal load and broken down into generating units so that one may be out for repairs or on standby at all times. For a proposed load of 740 kw this suggests three 500 kw turbine driven generators.

Now let's backtrack to the other side of the picture—the case in which the power plant is not isolated. For such a situation, I would suggest that the possibility of tying in with a public utility be investigated. It is quite possible that arrangements could be made for the power plant to be included in the local power network. Unfortunately, the peaks on the college plant will probably coincide with those of the public utility so that the college plant won't have the opportunity to sell much power. But by paying a demand and transformer charge, certain emergency lines could be supplied—for example, power house lighting, constant temperature experimental equipment, and hall lights in dormitories. For the proposed load of 740 kw, a 1000 kw turbogenerator would do the job and by obtaining emergency lighting the minimum power service to the campus could be provided at such times as the turbogenerator part of the power plant was shut down for repairs.

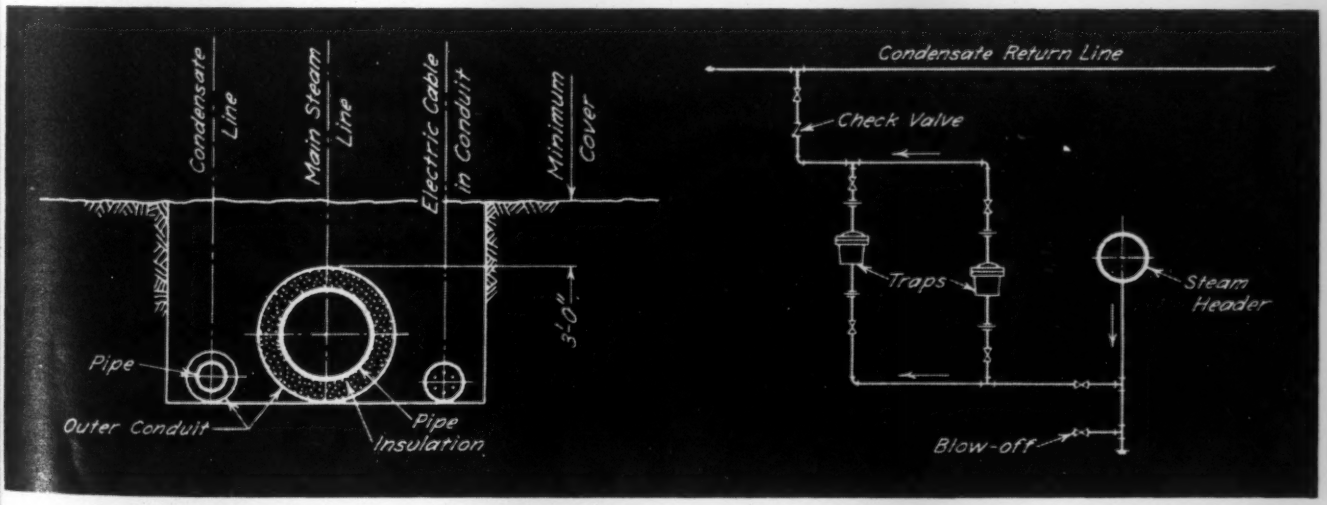
For the isolated plant there must be enough installed capacity so that power can be supplied to the campus under all conditions (destruction by an invading enemy, inundation, or so called "acts of God" being the only exceptions). If the chief engineer of an isolated plant (740 kw load) permits the installation of only 1000 kw, then he takes the rap everytime he has to clean a condenser, repair a pump, or do any of the normal maintenance jobs that would prevent him from having emergency power.

The existing equipment in the plant is obsolete. As pointed out, two of the boilers are over 40 years old. True, they can still generate steam, and the old steam engines can still convert the steam into mechanical power, but the entire equipment has served a long period of usefulness and should have been amortized years ago. Sell it for junk or to anybody that wants it and consider the money received as profit.

The new plant should produce only 60 cycle a-c power. Some of the present equipment using d-c power will be valueless, but as mentioned, adequate electrical facilities are not being provided so the loss won't be great. Future diversification can be taken care of easier with a-c power; everytime one of the faculty buys a piece of equipment, even though a ¼ hp motor is all that is required, it can be purchased cheaper if it uses a-c power. A-c power has many other advantages which need not be enumerated here.

For the isolated plant I would suggest that the turbine room contain three 500 kw turbogenerators, extraction type. As previously mentioned, a 1000 kw extraction unit would probably do the job if the plant can be tied in with the

Fig. 2 (left)—Typical installation of steam and condensate piping as suggested by "F.D.E." Fig. 3 (right)—"F.D.E." suggests this double trapping arrangement for proper drainage of condensate



QUESTION OF THE MONTH

area network for emergency service. In either case, it is probable that 2300 would be the best voltage to generate.

As for the steam generating units I would suggest two units of not less than 45,000 lb per hr capacity at 200 psig. Even though an emergency tie-in for electrical power is provided, there must still be enough capacity in one steam generator to carry the heating load for the campus whether the turbine is on or off the line. If the load is expected to fluctuate very much, I'd suggest that a boiler of more than two drums be considered. The fuel to use is an economic problem that will depend upon the local situation.

Steam Generating Units

Taking all things into consideration it is generally the best policy to use standard equipment when sizing units. Turbine manufacturers publish their standard items and also what bleed pressures are provided on standard turbines. The same thing should be watched in deciding upon steam generators.

For a power plant of the size being considered, I'd suggest that the matter of package units be carefully investigated. They are really snappy, well-engineered jobs. The boiler, pumps, condenser, turbine, generator, auxiliary driven equipment, and the whole works comes complete, properly sized and arranged for easy installation. One, two, or three of these units may be an excellent answer for the new plant.

Two Methods of Steam Distribution

There are several important things to consider in laying out the steam distribution system for the college. Two methods readily suggest themselves.

1) For buildings approaching 2000 ft from the boiler plant, run out with steam at boiler pressure and throttle at the buildings to operating pressure. For buildings close in, supply the distribution mains with bled steam from the turbines.

2) Supply all distribution mains with steam at 10 to 20 psig. This will carry to the remote buildings and necessitate some throttling at buildings close in.

The first method obviously involves less large piping but has the disadvantage that many tunnels or trenches will contain steam at two pressures.

The second method is much more flexible. All throttling is done at the boiler plant and not at several locations about the campus. The bled steam from the turbines can be used in any part of the distribution system. Of course the ideal situation is not to throttle any high pressure steam.

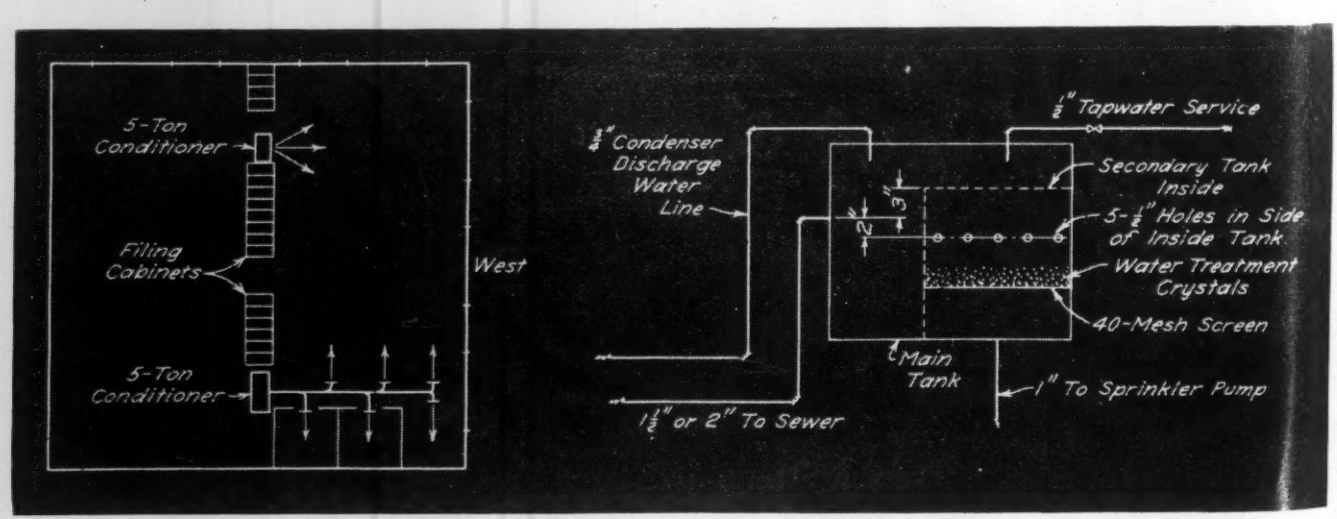
The condition of the present distribution system may govern which of the above methods is more economical. Perhaps many of the existing mains can be utilized when the new plant is laid out.—F.B.M.

Comfort Conditioning for Top Floor Space

I READ WITH great interest the Question of the Month in the June issue from "C.H.S." about keeping comfortable conditions in a large top floor drafting room. This is the kind of problem that keeps an air conditioning engineer's interest and forces him to be alert.

There are a number of additional facts needed in order to give the problem a complete analysis. For instance, "C.H.S." asked if evaporative cooling would be sufficient but did not state the locality. However, I should say that evaporative cooling will not meet his needs satisfactorily. Drafting papers are quite sensitive to moisture variations, and would be very adversely affected by the moist air from an evaporative cooler. One of the most difficult problems for a draftsman during hot weather, in a room not air conditioned with dehumidifica-

Fig. 1 (left)—"R.W.U." believes a satisfactory job of spot cooling could be done in the drafting room with self-contained units somewhat as shown here. Filing cabinets are arranged to restrict air movement from the unconditioned portion of the room. Fig. 2 (right)—Condenser water from the conditioners could be used for roof spraying, says "R.W.U." If the water contains impurities that would tend to clog the nozzles, it could be treated in a layout such as this



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tion, is perspiration. Also, in order to have satisfactory cooling (except in the very arid sections of the country) the air must be changed every minute to a minute and a half. This causes an air movement great enough to necessitate the weighting of papers, unless an elaborate distribution system is provided.

Evaporative coolers must be used with caution in most parts of this country. If I knew the particular locality in which this job is located, I could give a better idea of what could be expected from evaporative cooling.

So much for what not to use, in my opinion; now for the solution.

I feel that the system installed should meet the following requirements: dehumidification, low air movement and a dry bulb temperature low enough to afford comfort. Good design conditions would be: 78 to 80 F DB and 65 to 67 F WB. Again, not knowing the locality, I must make only rough cooling load calculations. However, it is very apparent that a very large part of the load is glass and roof.

To overcome the roof load I would install a roof spray system. This need not be an expensive installation, as I shall later explain. The rest of the load could then be taken care of with 3 ton or 5 ton self-contained air conditioners. The number and location of the units would depend on the load and air distribution desired. Based on 100 F outside temperature, four 5 ton conditioners should do a highly satisfactory job for the entire office. If only the section now in use is to be cooled, I believe that a very satisfactory job of spot cooling could be done with two 5 ton conditioners with an arrangement somewhat as shown in Fig. 1.

I would also investigate the cost of awnings for the west and south windows. Awnings would reduce the glass sun load by approximately 45 percent over inside venetian blinds, or 18,000 Btu per hr (1½ tons), based on my assumed 100 F outside temperature.

If the conditioners are operated from city water, the condenser water could be used for the sprinkler system. The sprinkler would only require 4 to 5 gpm. A centrifugal pump could be selected to deliver 5 gpm against 35 to 40 ft head.

A simple hookup could be made by running the condenser water to a small open sheet metal tank with a 1½ or 2 in. overflow to the sewer halfway up the side. A pipe could be run from the bottom of the tank to the pump suction connection. The tank should be approximately 2 ft above the pump to assure sufficient suction head.

Water Treatment

It would be desirable to be able to operate the sprinkler system when the conditioners were not in use. This can be accomplished by running a small tap water line to the tank. If the tap water used on the conditioners contains foreign ingredients which would tend to clog the nozzles, the water to the sprinkler pump could be treated as shown in Fig. 2.

The sprinkler pump discharge could be connected to the roof distribution system by ⅞ in. OD copper tubing or ¾ in. iron pipe. The roof system should be laid out and nozzles selected so as to give complete coverage of the roof. If the roof pipes are installed so as to pitch up slightly away from the point of supply, no further precautions need be taken against freeze-up. The water in the roof pipes will drain back into the tank each time that the system is shut down.

If it is necessary to use a cooling tower for cooling condenser water to the conditioners, it should be located on the prevailing-windward side of the building. It will then be necessary to operate the sprinkler system from tap water. Two or more self-contained conditioners can safely be operated from one cooling tower if care is taken in sizing pipes and balancing valves are installed.

Just as a point for consideration is the possibility of arranging the spray system so that a small amount of "mist" goes over the edge, thereby cooling the sides of the building to some extent. This would depend on the location and various other things pertaining to this particular building.

All of the equipment I have recommended can be moved should it become necessary to do so. All of the equipment constitutes a sound investment in increased efficiency and should pay for itself within a short time.—R.W.U.

QUESTION OF THE MONTH

Reader Wants Ideas for Air Conditioning To Protect Records

You are invited to answer the following question from "J.R.B." Suitable comment on this matter will be published, and paid for at regular rates (with additional payment for sketches). Address The Editor, Heating, Piping & Air Conditioning, 6 N. Michigan Ave., Chicago 2.

"I am faced with the problem of air conditioning a few rooms containing valuable old records, the idea being to prolong their life. I wonder what should be the proper temperature and relative humidity in these rooms. Is there any necessity of introducing outdoor air, or should outdoor air just sufficient to keep down the infiltration be introduced?

"The building is situated in an industrial town. I am told the outside air taken in is to be made slightly alkaline as the acidic nature of air would hasten the deterioration of the paper. If it is to be made alkaline, what should be the pH concentration and what should be the methods to make it alkaline easily?

"I understand that the humidity is to be maintained within a close range and hence an air washer will probably be used.

"I shall be thankful for any comments on this problem."
—J.R.B.

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"Open for Discussion"

DO YOU HAVE something to say about any of the articles published this month? An additional comment, or perhaps a question on some point? We follow here the custom of engineering society meetings in allowing a period for discussion following presentation of a paper. You are invited to contribute your views. Address the Editor, Heating, Piping & Air Conditioning, 6 N. Michigan Ave., Chicago

Practical Pointers on Radiant Heating Details

It is always a pleasure for me to read F. E. Giesecke's articles, because it is impossible not to recognize his unique and thoughtful avenue of approach to any of the problems relating to heating and allied subjects. Furthermore, because there are so many problems which confound the heating engineer, we as a profession welcome the assistance of those who have the opportunity to make observations and who have experience which is essential to decide on the relative value of such observations.

However, I am not surprised that Dr. Giesecke has recorded some floor temperatures as reported by him in his discussion in the July issue which differ somewhat from those given in my article in the June issue, because the conditions are so entirely different.

I selected designs which are commonly used in smaller buildings, and in so doing I called attention to the fact that a thicker concrete floor would help matters as regards uneven surface temperatures. My remark was: "If the concrete above the pipes is very thick, or a layer of material having low conductivity (such as a carpet, parquetry, or hardwood top flooring) covers the concrete, the intensity of the heat above the pipes is not so severe, etc., etc."

In Fig. A on page 98 in July, Dr. Giesecke gives the surface temperatures with concrete 6 in. thick, plus an additional 2 in. layer of mortar and tiles on the top of the concrete. In Fig. B he gives temperatures with a 7 in. concrete floor, and a layer of asphalt tiles as a finished flooring. Naturally, these two types of heavy floors can distribute the heat quite well, and the only disadvantage is the extra heat loss downward. This, however, can be taken care of by using a layer of insulation below the pipes. The question is, however, how often do we find floors to have concrete slabs 6 to 8 in. thick? In many jobs the pipes are placed only an inch or so below the surface, and then if the pipes are spaced wide apart, the difference in surface temperatures will be even greater than given in my article.

For reasons which I will explain later, I think it is necessary to point out that the surface temperatures given by Dr. Giesecke are already above the healthy temperature suggested by physiologists, and that these temperatures were taken with an outside of 33 F. I prefer to present figures taken under the worst outside weather conditions, because if we are calculating heat losses from a building on a basis of zero outside and 68 or 70 F inside, the temperature of the panel should be considered on this basis. If for an outside temperature of 33 F it is necessary to have an average surface temperature of 87.75 F, it is easy to imagine how much higher it will go when the outside drops to zero or perhaps −10 F.

Before any conclusions are drawn, it is very necessary that all figures relating to heating problems should be thrown into true perspective by the analysis and comparison of as many laboratory observations as is possible, with the overall results from many carefully prepared tests on installations. Simply to walk into a building and make observations without knowing and taking cognizance of all the conditions and changes which took place for a reasonable period previous to a test, and unobserved changes which take place during the test, is only asking for trouble. In the same manner it can be just as misleading to rely solely on laboratory tests without the knowledge of important changes which will occur on the actual installation.

In presenting any information relating to heating systems, I always

like to consider the heating contractor and to remember the many unforeseen problems which I had to face in that capacity. Those who have traveled along that road know the many pitfalls which await both the wary and the unwary. There are, of course, differences of opinion on many of these problems and, undoubtedly, there always will be differences, but to obtain the best results we have to interject our experience into our knowledge of physics and aim for the best. I know we often have reason to doubt, for even the method by which radiant heat energy is conveyed from a high temperature body to the surface of a lower temperature object is open to doubt.

However, my principal object in dealing with this question of floor heating in my original article was purely from a biological standpoint. I am certainly not raising this question of floor temperatures because of any personal adverseness to floor heating, because I favor a moderately heated floor in almost all instances, when other conditions are favorable. However, I receive so many letters asking for a remedy for floors which are too hot for comfort that I wrote the original article hoping it would have the effect of arresting the growing tendency for hot floors before it is too late and this method of heating falls into utter disgrace. These letters come from a cross section of the country, including home owners and industrial plants, so that the complaints are undoubtedly quite general.

In regard to the maximum permissible floor surface temperature, I am afraid I must differ with Dr. Giesecke's conclusions, because not only have my own personal experience and close observations of others who occupy rooms with heated floors substantiated my recommendations, but the general opinion of physiologists is also definitely in the direction of cooler floor temperatures.

Maximum Permissible Floor Temperature

Dr. L. P. Herrington, research director of the laboratory of hygiene, John B. Pierce Foundation, who has made an extensive study on the biological effect of warm floors on the human body, informs me that physiologists have for a long time known that comfortable alertness in a sitting or standing position is associated with relative low skin temperatures on the toes and underside of the foot; that is, temperatures of 80 F or below.

When I decided on a maximum floor temperature of 85 F, I based this on the lowest outside air temperature, which is usually zero or subzero, depending on the geographical location of the building. Under these conditions the average floor temperature for the winter will be approximately 75 F to 77 F, temperatures within the limit given by physiologists.

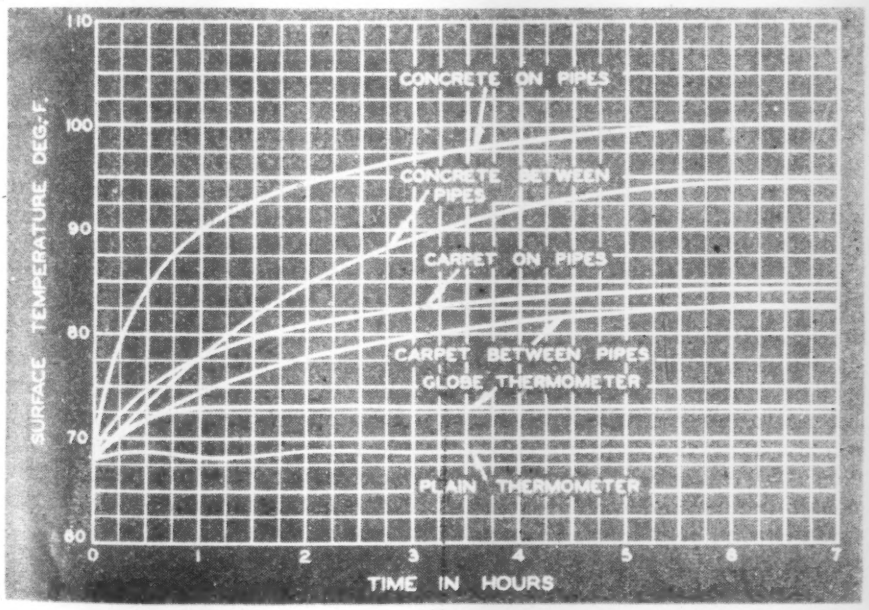
According to Dr. Herrington, there are very good reasons for the normal floor temperature to be below 80 F. These are connected with the body's task of maintaining an adequate circulation in the erect and semi-erect positions, and the problem is definitely affected by acclimatization changes on total blood volume.

This brings me to Dr. Giesecke's reference to the floor temperature which he measured in an unoccupied classroom during the summer vacation when he recorded floor temperatures of 93 F to 100 F. I think Dr. Giesecke will readily admit that there is a difference between the temperatures we can enjoy in the summertime and the temperatures which bring us comfort and health in winter.

If we refer to some of the valuable contributions published by the John B. Pierce Foundation, we shall find that physiologists tell us that foot temperatures below 80 F are quite common under comfortable winter heating conditions, and while the average lower extremity temperatures are well up in the 80's, the gradient is negative down the whole limb, and it is the local contact temperature that is important in determining the restriction in floor temperature. Dr. Herrington holds the opinion that people who adapt successfully to winter floor temperatures above 75 F do so by attaining a "summer acclimatization" status with respect to increased blood volume, although they are not, in fact, subject to a general summer level of temperature. This contraseasonal adjustment seems to be not only unnecessary, but for some people impossible.

My own office—like the rest of the offices in our plant—is provided with coils in the ceiling as well as coils in the floor, and for several years I have spent two or three evenings a week in my office up to 11 or 12 o'clock during the winter months. On many occasions during very cold weather I have shut off the ceiling coils after ordinary working hours and have boosted the floor surface temperature to maintain the correct effective temperature. This was done to record the effect on my own alertness, and

Fig. 1—Results of a test by Mr. Adlam showing effect of broadloom carpet on a concrete floor

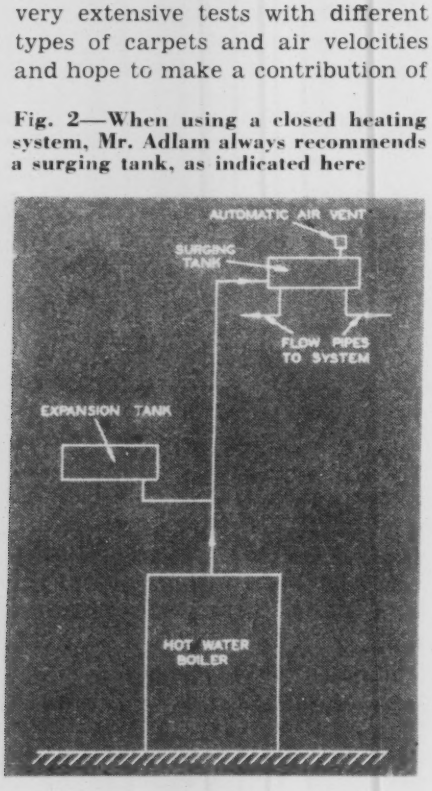


almost without exception I could feel the adverse effect as the floor temperature passed the 85 F mark and reached 90 F. This effect was not only noticeable on the feet, which ordinarily never trouble me, but was also associated with the general feeling of alertness. On those occasions when I changed back to normal conditions and produced a lower floor temperature, the alertness returned, showing conclusively that the floor temperature can affect the physiological conditions of the body. There is undoubtedly considerably more to this physiologically than a comfortable skin temperature, and after many years of experience and careful observation, my sincere advice when floor heat is to be used is to provide conditions and sufficient panel area so that the surface never goes above 85 F, and a fairly equable temperature is maintained over the whole area.

Effect of Carpets on Heat Output

The effect of carpets is a very problematical subject because of the many types available, and the varying effect of felt pads generally used under the carpets. During the past winter I have conducted some very extensive tests with different types of carpets and air velocities and hope to make a contribution of these data as soon as time permits. I am, however, giving in Fig. 1 a chart made from actual tests with a broadloom carpet on a concrete floor without felt pad. Even without the additional data which, for lack of space, cannot be given here, I think this chart will clearly indicate that carpets do reduce the temperature of the surface and also the heat emission.

Fig. 2—When using a closed heating system, Mr. Adlam always recommends a surging tank, as indicated here



In perusing Dr. Giesecke's experience with asbestos covering over metal ducts, I am struck by the fact that this incident appears to be similar to the experience of James Watt, the eminent engineer, when he tried to obtain radiant heating by using polished metal panels more than 150 years ago. This was, of course, before Leslie discovered the emissivity effect of different surfaces, especially in connection with polished surfaces. This same principle was also clearly demonstrated by covering polished copper with paper, and using the equipment illustrated on page 42 of my book, Radiant Heating.

It would, however, be very misleading to assume from any of these tests that by placing a carpet on the floor we get a greater output of heat. It would be as logical as wearing an overcoat in hot summer weather to increase the heat loss from the human body, hoping to feel cooler. It is true that heat will gradually penetrate through the fabric, but in every test I have made with carpets it has been necessary to boost the water temperature to get equal results. Furthermore, if it were true that by placing any kind of material over a hot surface we increase the heat loss, why are we so careful to cover with expensive insulating material steam and hot water pipes to economize in fuel consumption?

Why Piping Leaks Were Mentioned

My object in bringing the subject of leaks into my article was simply as a word of caution. It is well known that while a welded joint may be perfect, the metal a short distance away from the joint may become hard and brittle. This is where I have noticed most of the trouble occurs, and with very long straight runs of pipe with a number of welded joints there is a positive danger of some shearing taking place. It is not always the engineer or contractor who suffers, because very often the trouble develops long after the responsibility has shifted to the owner. I have had the responsibility of workmen for too many years to believe that all work done is perfect, and if we aggravate this by designing systems with inherent weaknesses, we are largely to blame.

As to Dr. Giesecke's method of stopping a leak, I too have used cement to stop leaks in pipes and tanks, and my memory goes back to the time when, as an apprentice, I helped to fill in with cement the cracked base of a 4 ft diameter vertical steam cylinder and jet condenser on one of the old Bolton & Watt steam engines, but I have, however, seen too many troublesome jobs to treat these matters lightly. Yes, we can find ways of overcoming difficulties, but I am sure that Dr. Giesecke will readily endorse my sentiments when I say that we, as engineers or contractors, have no license to condone or excuse faulty design or inferior workmanship just because our ingenuity enables us to devise some remedy which, to say the least, is often open to doubt.

Good Air Venting Is Essential

The value of good air venting can only be appreciated by experience, and I have seen some very sad cases simply because this question of air venting was treated lightly. Air venting is serious in any kind of hot water heating, and it is more so in connection with long flat coils as used with radiant heating.

Within a few miles of where I now write there is a charming residence. Charming in every respect except the heating. Coils are installed in both floor and ceiling, but owing to air locks two bedrooms have had no heat since the house was built. Two high lift pumps were installed last winter to overcome the trouble, but without effect. Extra power and greater noise were the only changes effected. It was brought to my attention a few weeks ago and it will mean cutting into the structure and inserting air vents before any circulation will be achieved. This is one of the many serious examples of which I refer, but most engineers have heard the

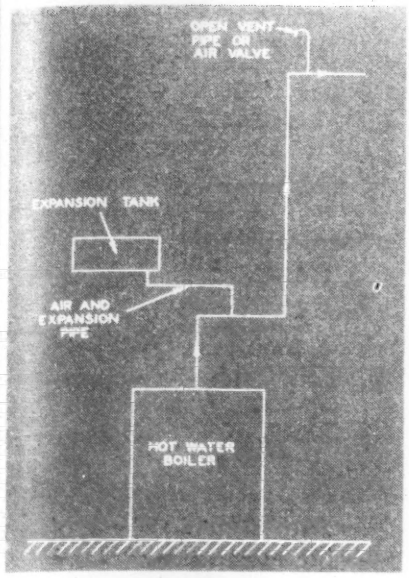


Fig. 3—If we rely on a connection as shown here, says Mr. Adlam, we shall find that the entrained air is carried along with the high velocity water past the tee connection

gurgling noise which is characteristic of air traveling with water through a pipe, valve, or fitting. This could be entirely obviated if proper precautions were taken to air vent the system correctly.

I, too, like the principle of the open tank to eliminate all air, but the tank should be placed so that air can leave the water freely and discharge above the tank. When using a closed heating system I always recommend the introduction of a surging tank, as shown in Fig. 2. With this method it is necessary to use only a comparatively small tank, and on small installations an enlarged pipe will suffice.

With most installations we shall find that small bubbles of air will collect in fittings and in the enclosed passages of pipes and valves, even though every high point in the system is properly air vented. When the system is started up, these air bubbles, and also the air expelled from the water as it is heated in the boiler, will travel through the system entrained with the water. It is the passage of these air bubbles through restricted areas which creates noises like peas traveling along a tube, or like water trickling over large stones. The interruption of the flow of water by the sudden change in direction which takes place in the surging tank shown in Fig. 2 will provide the means for air to leave the water and rise to the top of the tank where it can be expelled through an automatic air eliminator.

There are, of course, other effective methods of eliminating air from the water stream, but this method is infinitely more effective than simply connecting an air pipe to the top of the main flow pipe. It also has the added advantage of not being very expensive.

If we rely on a connection as shown in Fig. 3 we shall invariably find that the entrained air is carried along with the high velocity water, past the tee connection, and will continue its capers and characteristic noises all over again.

I do not think any experienced heating engineer would attempt to run hot water circulating pipes up and down at will and expect to get good results. What may happen as a freak result with one or perhaps two circuits should never be taken as a guide to tempt the unwary when dealing with a system with a number of circuits.

It is quite possible that the old pipe joints referred to by Dr. Giesecke were sufficiently porous to allow air slowly to pass through and air vent some of the pipes, without being sufficiently porous to allow water to leak through. I have often found this when dealing with old systems in mansions and cathedrals.—T. NAPIER ADLAM, vice president, Sarco Mfg. Co., Bethlehem, Pa.

PROTECTING MATERIALS BY DEHUMIDIFYING

I HAVE READ Commander George Wells' article on Dehumidification Protects Materials from Deterioration in the August issue, and would like to submit a few comments for the "Open for Discussion" pages.

This is undoubtedly one of the most important articles on this subject that has been written to date because it gives detailed results of approximately three years of practical application of dehumidification for protection of materials of all types. From our practical experience in the storage of materials for land operations, we have found some minor differences which I would like to bring out:

1) It is not necessary in the typical storage building to go as low as 30 percent relative humidity for adequate preservation. We have found that relative humidities between 40 and 50 percent are sufficient. This is not contrary to the Navy research program, but is predicated on the fact that with the heavier construction, lower heat capacity of building materials, and control lag in temperature variations of a storage building as compared to a steel hull ship, the rapidity of the change of relative humidity inside the building is much lower than that of a vessel; consequently, it is not necessary to maintain as low a humidity in a storage warehouse to maintain an average condition, as is necessary on board ship, unless the warehouse is of steel construction which would have the same heat transfer rate and time lag as a ship hull.

2) The standard commercial method of controlling the equipment is through a single humidistat operating the dehumidifier on a positive control of relative humidity rather than using multiple humidity indicators through an averaging device. The main reason for this is that in practically all installations to date the dehumidifier controls only one space. When there are a number of spaces to be controlled, general practice is to install a small dehumidifier in each space so that these spaces can be controlled independently, depending on the requirements.

I have had occasion the past few months to inspect naval vessels on the west coast which have been in preservation for nearly three years and can corroborate Commander Wells' statement as to the efficacy of dehumidification as an inexpensive means of insurance. I have also made inspection of vessels which were preserved by means other than dehumidification and the comparison between the two leaves no doubt in my mind that dehumidification is the answer to these problems.

The vessels which were not dehumidified showed excessive corrosion and damage to main propulsion turbine blades, pump impellers, electric motors, and switchgear as well as auxiliary equipment and bulkheads and other structural members. The cost of placing these ships back in service is far in excess in both time and money of the cost

"OPEN FOR DISCUSSION"

of protective dehumidification.

I certainly hope Commander Wells will be in a position at some time in the near future to publish another such article in which he can give an economic survey as to costs of activation of ships with and without preservation, with comparative photographs showing the enormous damage extant in vessels which have not been dehumidified. —JOHN EVERETTS, JR., Urdahl and Everetts, consulting engineers, Washington and San Francisco.

FUEL COST LOWERED USING GAS IN SUMMER

A. B. STICKNEY'S article in the August HPAC, on design problems involved in the conversion of industrial plants from solid or liquid fuel to gas for part-time operation, is especially opportune at this time in the Chicago area. What has brought about the interest in such conversions is of course, the comparison that presently exists between costs per 100,000 Btu for coal, oil, and gas.

The gas company serving the Chicago territory has a rate for gas available for industrial users between April 15 and October 15, as approved by the state commission, that (while it varies with the quantity used) will average about 2c per therm (100,000 Btu) for most industrial plants. This corresponds to $4.80 per ton for 12,000 Btu per lb coal, and 3c per gal for fuel oil with a heat value of 150,000 Btu per gal. Coal and fuel oil prices are today considerably above $4.80 per ton and 3c per gallon delivered.

An analysis of one plant made by me showed that it burned 16,000 tons of screenings between April 15 and October 15 last year, which would cost at present prices $8.60 per ton or a total of $137,600 for the season. The same heat value could be obtained at the summer gas rates for $76,800 if the combustion efficiencies were the same for both fuels. The apparent saving of $60,000 in fuel costs for one season was too great to be ignored, so the conversion was made with the assurance that plant alteration costs would be recovered the first season. The same reasoning has brought about 300 conversions in this area.

Before undertaking a conversion to gas, especially from coal to gas for summer use, the engineer should carefully consider the existing furnace setting design with special reference to ease of returning the plant to coal burning on October 15, and reconversion again next April, the length of throw of gas flame before striking any boiler tube or drum, volume of combustion space, and provisions for keeping tubes clean; temperatures in a gas fired furnace will likely be 400 deg higher than in a coal fired furnace so the heat transfer rate through the tubes at some places may be high, requiring the maintenance of clean tube surfaces.

The present cost ratio between gas, solid, and liquid fuels is so favorable for gas for summer load operation the plant owner can well afford to overcome many obstacles to make its use possible.—JOHN HOWATT, chief engineer, Chicago Board of Education; member of HPAC's board of consulting and contributing editors.

PRECAUTIONS ESSENTIAL IN USING SOLVENTS

I WISH TO CALL attention to a statement which appears on page 96 of the July HPAC.

The author of the article in question states that carbon tetrachloride may be brushed or sprayed on fans to aid in removing accumulated deposits.

Carbon tetrachloride is one of the most harmful of solvents as far as its action on humans is concerned, producing severe liver damage which in many instances may prove fatal. One of the fundamentals in the use of solvents is to remember that the best solvent for the job is usually the worst for the operator, from a fire hazard or toxicity standpoint or both.

If it is necessary for operators to use a toxic solvent, there are other solvents with flashpoints over 100 F which may be substituted for carbon tetrachloride. In any event, proper glove and personal respiratory protection in the form of organic vapor masks or air supplied respirators should be provided for and used by operators who handle toxic solvents. Since many of the toxic solvents used in industry are not very irritating as far as odor is concerned, operators usually are exposed to high concentrations of the vapors before it is realized that irreparable damage has been done.

If carbon tetrachloride is used to clean the inside of ducts, and I consider this a very dangerous operation, special care should be taken to see that the operator is properly protected as noted above together with the possible operation of the system to aid in removing vapors of the solvent to the outdoors and a watcher whose function it should be to periodically check the activities of the operator.—BENJAMIN F. POSTMAN, industrial hygiene engineer, Employers Mutuals of Wausau, New York City.

IMPROVING PIPING FOR REFRIGERATION

THE WRITER enjoyed very much reading the article in the June issue, Improved Piping Design Aids Refrigerating Plant Results, by Herman Vetter. We find that many of the inefficiencies of plant operation can be traced to improper piping design in refrigerating plants.

It has been our observation, too, that even the operators eager for improved results are unable to find proper material as a pattern of thought, as well as the answers to correct or better present inefficiencies of their installations.

In the past we have noticed several articles of this nature in HPAC, and want to applaud your thought in presenting this constructive information as simply and understandably as in this article.—W. F. LOSCH, Frick Co., Los Angeles.

HOW TO SELECT COMBUSTION CONTROLS

FRED MEYER'S very complete article on selecting combustion controls as published in the July HPAC is of such interest to us that we would like to obtain additional copies for our various representatives.

Some publications arrange to provide reprints of worthwhile articles. If such reprints are, or will be available, we would like to obtain approximately 25 sets. Naturally, we would be glad to absorb our share of the expense involved.

Again, I would like to compliment the author for the preparation of this article.—A. B. MEEG, industrial controls div., Perfex Corp., Milwaukee.

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Heating, Piping & Air Conditioning

AMERICAN SOCIETY of HEATING and VENTILATING ENGINEERS

Journal Section

Thermal Insulation of Clothing

By C. P. Yaglou*, Boston, Mass.

SUMMARY — Two principal methods of evaluating clothing insulation were used in the past war. These were (1) the *heat loss method* employing physiological and physical observations, and (2) the *temperature gradient method* in which only temperature measurements were required. In both methods the clothing was worn by subjects exposed to conditions simulating those for which the clothing was intended. Results obtained by the two methods differed by 10 to 30 percent, due probably to the difficulty in the *heat loss method* of estimating the body heat debt on exposure to cold, and due partly to inability to take all major factors into account.

The *temperature gradient method* permits evaluation of insulation over different parts of the body, and this is an advantage because adequacy of cold weather apparel depends on insulation obtained over critical body areas. Test results obtained by the two methods are used to illustrate their comparative value.

THE PURPOSE of clothing, as everyone knows, is to provide thermal insulation that will spare bodily effort in adaptation to environmental changes. What is not well known is, how much insulation is offered by various kinds of clothes, and how much insulation is required to maintain comfort at rest or work under various environmental conditions.

Although the insulation value of samples of fabrics composing a garment can be measured readily by the hot plate or the cylinder method, such simple measurements are of no great value in predicting the warmth of the garment to the wearer. The style, looseness of fit, porosity, compression, moisture retention, and stiffness of fabric resulting in *bellows action*, can modify considerably the effectiveness of fabric insulation. Tests must, therefore, be made on persons wearing the clothes and exposed to environmental conditions simulating those for which the clothes are intended.

In the last war, much research was sponsored by the military services to gain information for designing uniforms suitable for practically every climate of the world from the arctic to the tropics. Two principal methods were developed for evaluating clothing insulation, the *heat-loss* and the *temperature-gradient* method. The purpose of this paper is to discuss the usefulness and limitation of these methods.

Heat-loss Method for Estimating Overall Insulation of Clothes

This method, first proposed by Gagge, Burton, and Bazett[1], is used for evaluating overall insulation of cold weather clothing. Subjects wearing the clothes to be tested are exposed to a suitable temperature, in a refrigerated room, for two to three hours until the body cooling rate becomes nearly steady. Observations are then made of metabolic rate, moisture loss, and of skin, rectal, and air temperatures, from which the thermal resistance of clothes is computed by using the following heat balance equation:

$$H_{cl} = A_s \frac{(t_s - t_a)}{R_{cl} + R_a} \quad \ldots\ldots (1)$$

where

$$H_{cl} = M + 0.83W \frac{(2\Delta t_r + \Delta t_s)}{3} - 1040P \quad \ldots\ldots (2)$$

* Professor of Industrial Hygiene, Harvard School of Public Health. Member of ASHVE.

Presented at the Semi-Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Bretton Woods, N. H., June 1948.

[1] Exponent numerals refer to References.

and

$$R_{cl} = \frac{A_s\,(t_s - t_a)}{M + 0.83W\,\dfrac{(2\,\Delta t_r + \Delta t_s)}{3} - 1040P} - R_a \quad \ldots\ldots (3)$$

Using the British system of units throughout,

H_{cl} = *sensible* heat loss through the clothing, in Btu per hour, assuming a negligible amount of air leakage into and out of the clothing.

A_s = Total body skin area estimated by the method of DuBois[2], square feet.

M = Total metabolic rate, Btu per hour.

0.83 = Average specific heat of human body, Btu per (pound) (Fahrenheit degree).

W = Weight of unclothed subject, pounds.

Δt_r = Rate of fall of rectal temperature, Fahrenheit degrees per hour.

Δt_s = Rate of fall of mean skin temperature, Fahrenheit degrees per hour.

$0.83W\,\dfrac{(2\Delta t_r + \Delta t_s)}{3}$ = Body heat debt, or loss of intrinsic body heat, due to decreasing skin and rectal temperatures.

1040 = Heat of vaporization of perspiration at skin temperature, Btu per pound. It is assumed that vaporization takes place at the surface of the skin, and that the vapor passes through the clothing without condensation.

P = Moisture evaporated from skin and lungs, pounds per hour.

R_{cl} = Thermal resistance of clothing assembly, Fahrenheit degrees per (Btu) (square foot) (hour).

R_a = *Thermal resistance of air*, Fahrenheit degrees per (Btu) (square foot) (hour). This is the reciprocal of *film conductance* (f) representing the combined heat transfer to and from the outer clothing surfaces by radiation, conduction, and convection.

Heat-loss in warming the inspired air is usually neglected when subjects are resting, but should be taken into consideration when subjects are engaged in heavy physical work.

Recently, a new unit of clothing insulation, the Clo, has been adopted, to represent the insulation value of ordinary indoor clothes that are capable of keeping a man comfortable in still air at 70 F with relative humidities of less than 50 percent. It has been estimated[1] that a Clo is equivalent to a thermal resistance of 0.88 F deg per (Btu) (hr) (sq ft), or to a conductance of 1.14 Btu per (sq ft) (hr) (F deg).

Substituting this value in Equation 3;

$$I_{cl} = \frac{1.14\,A_s\,(t_s - t_a)}{M + 0.83W\,\dfrac{(2\Delta t_r + \Delta t_s)}{3} - 1040P} - I_a \text{ in Clo units} \quad \ldots\ldots (4)$$

The *insulation of air* I_a approximately can be computed from the following expression suggested by Burton[3]:

$$I_a = \frac{1}{0.61\left(\dfrac{460 + t_a}{537}\right)^3 + 0.135\sqrt{\dfrac{V \times 537}{460 + t_a}}} \text{ in Clo units} \quad \ldots\ldots (5)$$

where

t_a = air and wall temperatures in Fahrenheit degrees.

V = air movement, in feet per minute.

Values obtained by this equation are fairly close to corresponding f (surface conductance) values given in the HEATING, VENTILATING, AIR CONDITIONING GUIDE 1947. For example, if $t_a = 70$, and $V = 25$ fpm, $I_a = 0.79$ Clo by Equation 5, and $f = 1.44$; if $V = 1000$ fpm, $I_a = 0.20$, and $f = 5.68$.

Only the overall insulation can be studied by this method. Observations are usually made with subjects at rest and with all closures properly fastened to prevent air leakage into and out of clothes. Such tests give the maximum insulation rating. In subfreezing temperatures it is desirable to keep hands and feet at a neutral temperature (65-75 F) by means of electrically heated gloves and footwear, although this is seldom done. Without artificial heating, the extremities will cool down quickly and may set a limit to the endurance even though other parts of the body may be adequately protected.

With subjects at work, clothing may lose much of its insulation due to wetting by perspiration, and to increased ventilation due to pumping action. This is of advantage in preventing accumulation of sweat during work in the cold, and in alleviating chilling during rest after the exercise.

Temperature-Gradient Method for Evaluating Local and Overall Insulation[4]

This method has a broader scope and yet it is simpler than the heat-loss technique, as it involves measurement of temperature gradients only, with subjects similarly exposed. The underlying principle is that, barring appreciable air leakage into and out of the clothes, the amount of sensible heat passing through any particular area of a garment or combination of garments, is equal to the heat lost from corresponding areas of the outermost garment by radiation and convection to the external environment.

The following equations should therefore hold for heat flow through outer garment areas:

$$\frac{(t_i - t_o)}{I_o} \times \frac{(A_i + A_o)}{2} = \frac{(t_o - t_a)}{I_a} \times A_o \quad \ldots\ldots (6)$$

and

$$I_o = \frac{(t_i - t_o)}{t_o - t_a} \times \frac{(A_i + A_o)}{2A_o} \times I_a \quad \ldots\ldots (7)$$

Likewise the composite insulation of underclothing and trapped air layers is given by:

$$I_u = \frac{(t_s - t_i)}{t_o - t_a} \times \frac{(A_s + A_i)}{2A_o} \times I_a \quad \ldots\ldots (8)$$

and the overall insulation of an assembly as a whole is given by:

$$I_t = \frac{(t_s - t_o)}{t_o - t_a} \times \frac{(A_s + A_o)}{2A_o} \times I_a \quad \ldots\ldots (9)$$

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Table 1—Insulation Values of Men's Winter and Summer Clothes

(Estimated by the heat-loss and temperature-gradient method from observations on a group of 22 men resting comfortably in air conditioned rooms[5].)

	Winter Season	Summer Season
Average weight of clothes excluding footwear, lb	6.4	3.0
Air and wall temperature, F	72	80
Approximate relative humidity, %	30	55
Approximate air movement, fpm	20	20
Mean skin area of whole body, sq ft	20.3	20.1
Skin area covered by clothes, sq ft	16.2	15.8
Outside surface area of clothes, sq ft	19.7	18.6
Metabolic rate, B t u/hr	375	372
Moisture evaporated from lungs and skin, lb/hr	0.11	0.16
Average skin temperature under the clothes, F	92.8	93.8
Average outside surface temperature of clothes, F	81.7	88.0
Insulation of air computed by Equation 5, Clo	0.84	0.82
Insulation of air computed from above data, Clo	0.83	0.83
INSULATION OF CLOTHES by heat-loss method, Clo	1.02	0.71
INSULATION OF CLOTHES by temperature-gradient method, Clo	0.87	0.55

Table 2—Overall Insulation Value of a Military Wool-pile Uniform (10.2 lb) Worn over Cotton-wool Underclothing (2.2 lb). (Computed by the heat-loss method from observations on two subjects, after an exposure of 2½ hr to an average temperature of —1.4 F with 20 fpm air movement. Hands and feet electrically heated to about 75 F)

Average weight of two subjects, lb		158
Average skin area of whole body, sq ft		21.1
Total metabolic rate after 2½ hours of exposure, B t u/hr		445
Mean skin temperature under the uniform, 2½ hours, F		82.4
Rate of fall of mean skin temperature, 2½ hours, F deg/hr		0.60
Rate of fall of rectal temperature, 2½ hours, F deg/hr		0.45
Moisture evaporated from skin and lungs, lb/hr		0.05

$$I_{cl} = \frac{1.14 \times 21.1\ (82.4 + 1.4)}{445 + 0.83 \times 158\ \frac{(2 \times 0.45 + 0.60)}{3} - 1040 \times 0.05} - 1.0 \quad \text{Clo} \quad 3.4^a$$

[a] For whole assembly, as against 3.0 Clo, obtained by temperature gradient method in Table 3.

Table 3—Insulation Value of Wool-pile Uniform Described in Table 2

Computed from simultaneous observations of temperature gradients. Skin area under the uniform, 17.2 sq ft. Outside surface area of uniform, 22.6 sq ft. *Insulation of air*, 1.0 Clo.

Area Under Observation	Mean Temperature F: Skin-underwear (t_s)	inside pile surf. (t_i)	outside pile surf. (t_o)	Clo values: underclothing (I_u)	pile garment (I_o)	Total (I_t)	Pressure lb/sq in.	Thermal Sensation
Shoulder	82.6	53.5	11.6	1.8	3.0	4.8	0.00	cold
Chest	86.4	44.2	17.1	1.9	1.4	3.3	0.05	cool
Abdomen	88.8	38.1	14.9	2.5	1.3	4.0	0.02	cool
Back	86.9	71.3	23.5	0.5	1.8	2.2	0.25	cold
Low Back	87.3	37.9	18.1	2.1	0.9	3.1	0.30	cool
Upper arm	78.4	50.3	10.6	1.9	3.1	4.9	0.05	cold
Elbow, bent	69.2	49.7	18.8	0.8	1.4	2.2	1.00	very cold
Forearm	73.3	56.2	17.4	0.7	2.0	2.6	0.15	cool
Jacket, wghtd. mean	83.9	50.2	16.2	1.6	1.8	3.4	—	cold
Seat	77.4	69.4	59.6[a]	0.2	0.4	0.6	13.30	cool
Thigh, front	83.4	60.9	19.3	0.8	1.8	2.6	0.20	cool
Thigh, back	80.1	63.6	22.2	0.5	1.7	2.0	0.10	cool
Knee cap	68.9	48.7	17.6	0.8	1.5	2.3	0.75	cold
Shin	73.5	43.1	12.7	1.7	2.0	3.6	0.00	cool
Calf	70.5	38.3	9.1	2.4	2.6	5.0	0.00	cool
Trousers, wghtd. mean	77.0	55.1	17.6	0.9	1.8	2.7	—	—
Jacket and Trousers	80.5	52.7	16.9	1.2	1.8	3.0	—	cold

[a] Temperature of trouser seat in contact with chair. Equivalent trouser seat temperature in contact with air = 24.9 F.

Table 4—Thermal Insulation of Two Types of Military Footgear, Estimated by the Temperature Gradient Method

Subjects working (step-climbing) in a temperature of 19.2 F with trouser cuffs tucked into the boots. Air movement over boots, 95 fpm. Insulation of air by physical tests, 0.5 Clo.

	Combat boots with cushion sole socks		Shoepac with cushion sole and ski socks	
	Footskin Temp. F	Boot surface Temp. F	Footskin Temp. F	Boot surface Temp. F
Base of toes	75.8	—	83.0	—
Sole	79.3	33.6	88.0	30.4
Arch	80.2	37.0	89.3	33.1
Heel	80.9	29.2	92.9	28.7
Around sides of foot	75.8	43.6	83.8	30.2
Around ankle region	84.8	43.8	87.3	39.3
Around lower calf and shin region	86.4	45.7	89.7	38.1
Weighted mean temperature	81.8	42.6	87.0	35.1
Insulation value of footgear	0.76 Clo		1.32 Clo	

where

t_i and t_o = inner and outer surface temperature of garment being tested

t_s and t_a = *skin-underwear* temperature, and air-wall temperature

A_i and A_o = inner and outer surface area of garment being tested, estimated by Simpson's rule

A_s = skin area covered by clothing being tested, estimated by the method of Du Bois[2]

I_o and I_u = thermal insulation of outer garment, and of underclothing including resistance of trapped air layers

I_a = surface resistance of outer clothing, *insulation of air*, approximately computed from Equation 5, or more accurately determined by the hot cylinder or hot plate method, using samples of fabrics being tested

If t_s, t_i, and t_o, are spot temperature readings, the computed insulation will be that of the spot under observation. Substitution of weighted mean temperatures of a segment, a whole garment, or of a whole assembly in Equations 7, 8 and 9, will give the mean insulation of the item under consideration (see Table 3).

Temperature gradients are measured on at least fifteen areas of the body (Table 3) by thermocouples of No. 30-35 gage wire, sewed onto the innermost surfaces of the underclothing, next to the skin (skin-underwear temperature), and on corresponding areas on the inside and outside of the outermost garments. Thermocouple junctions attached to exposed surfaces are covered with a strip of adhesive tape. Pile temperatures of unlined shearling or wool-pile garments, can be measured approximately by thermocouples fastened to discs of light, loosely woven cotton cloth, sewed onto the shearling skin or to the pile fabric without compressing the fibers.

Gloves, footwear, and headgear are wired and tested as separate items (see Table 4) unless they are integral parts of a uniform. In subfreezing temperatures, boots and

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gloves are tested with men walking, or step-climbing at a steady rate, in order to keep the feet warm without applying external heat. The trouser cuffs usually are tucked into the boots to prevent air leakage.

Wherever possible, it is desirable to keep the air movement low because the outer surface temperature of heavy clothes approaches air temperature with high velocities and, therefore, even small errors in measuring surface temperatures might significantly affect the results. If high velocities are essential to the purpose of tests, a greater number of surface thermocouples must be used.

Comparison of Two Methods

In Tables 1 to 4 are shown results obtained by the two methods with various clothing assemblies. The heat-loss method, as a rule, gives from 10 to 30 percent higher insulation ratings than does the temperature-gradient method; and when hands and feet are inadequately protected, the discrepancy may be even greater. Sweating or shivering may further complicate the comparison.

One important difficulty is the lack of a method for estimating body heat debt in low temperatures, as Winslow[6] et al have shown recently. The factors of 2 and 1 in Equation 3, by which changes of rectal and skin temperatures respectively are weighted, do not remain constant, but vary with environmental conditions and with individual constitutional factors. The tendency in subfreezing temperatures is to under-estimate the heat debt, and this in turn leads to an over-estimation of insulation. Although moderate heating of hands and feet appears to give more concordant results by the two methods, there is no way of predicting the effect of external heat on mean skin temperature, heat debt, and heat-loss. This effect can automatically be compensated by measuring temperature gradients across the surfaces of garments, as is done in the gradient method, but not in the heat-loss method.

The only gradient conventionally measured in the heat-loss method is that from the skin to external air. Any extraneous influence on skin temperature, such as the effect of previous environment, the specific dynamic action of food eaten, insulation of gloves, footgear, and headgear, psychological disturbances, etc., can produce irrelevant variations of the overall gradient and of insulation value.

Some workers have attempted to overcome such difficulties by using electrically heated copper dummies in which skin temperatures and heat-loss through garments can be accurately measured. In effect this is a reversion to the hot cylinder method. The only advantage is that a full-sized dummy takes account of body shape factors which are important in studying insulation of gloves and boots. Other workers have looked into the possibility of estimating insulation from the total thickness of air spaces and fabric layers measured on human subjects.

The most serious limitation of the heat-loss method is that it deals only with overall insulation of whole assemblies, and cannot be applied to evaluating insulation on body areas that are particularly sensitive to cold, such as the shoulders, back, elbows, knees, hands and feet. As can be seen in Table 3, different parts of the body require different amounts of insulation, and clothing must therefore be designed in accordance with these facts. Inadequate protection of critical areas greatly reduces endurance to cold even though the overall insulation of an assembly may appear adequate. It is clear that the heat-loss method falls too short of the purpose for which it originally was intended.

The temperature-gradient method was developed especially for evaluating insulation of critical areas, gloves and boots, or of whole assemblies[4]. It provides information for studying the cause of failure at break-down points of garments, from a consideration of local skin temperature and insulation value, possible air leakage, compression pressure, and sensations of warmth (see Table 3). It is not necessary to know the metabolic rate, rectal temperature, body heat debt, or heat-loss by evaporation in this method. It is important, however, that the insulation value of air be accurately estimated because this quantity appears as a multiplier in Equations 7, 8 and 9.

Although results so far obtained by the gradient method appear promising, there is not enough experience to judge its possibilities and limitations at this time.

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Discussion

H. C. Bazett,[7] Philadelphia, Pa. (Written): Professor Yaglou's paper is interesting and he certainly is right in concluding that our methods of measuring the insulation of clothing are far from adequate. I fully agree with his criticisms of the heat loss method for which Burton was mainly responsible and of the rough quantitative deductions, to which my name is attached, which were mainly developed by Gagge. Unfortunately, I am not fully convinced that the *temperature gradient method* is any better. However, by the use of the two methods we do have some gain, for the sources of error of the two are different.

The heat gradient method depends on the use of the insulation of air as a

[7] Professor of Physiology, School of Medicine, University of Pennsylvania.

standard. It is an uncertain standard. It can be measured, it is true, by a hot cylinder method but it remains doubtful whether the value so obtained applies to conditions of the body or of clothing as worn. The insulation of the air is well recognized to be greater for a plane surface than for a cylinder, and to be less for cylinders of small radii. A cylinder of the approximate radius of the arm or leg could be used, but how is one to estimate accurately the integrated value of the radius for a limb with elbows and other irregular excrescences?

The thermal gradient estimates given in this paper are some 88 percent lower than those determined by heat loss for winter conditions, while the difference is even greater for the summer clothing. However, recent work by one of my students, Mrs. L. Love, on the heat loss from a bare foot in cold and warm conditions (maintained unchanged for days), demonstrates that the insulation value of the air circulating around the foot within a calorimeter (which was utilized to measure the insulation, probably with reasonable accuracy) at the same air velocity is entirely different in cold and warm conditions. This is not a physical change but a physiological one, for it is found on a bare foot, but not on a boot heated from within by an equivalent amount of heat. One factor in its causation is that the individual exposed to heat and adapted to it, loses heat mainly from the toes and similar skin areas covering cylinders of small radius. Under cold conditions the toes are allowed to cool so that their temperatures differ little from that of the environment and the heat loss then is mainly from cylinders of larger size. Thus, in this case at least, the insulation of the air is not a physical constant but can be varied by physiological adjustments. The phenomenon here referred to concerns convective heat loss and it appears impossible to attribute it to confusion with evaporative loss.

Professor Yaglou and I do not disagree so much as might first appear, for we both feel that methods must be much more fully developed to give accurate results. Also, we both find it much easier to see the mote in the other's eye rather than the beam in our own. Such friendly rivalry ultimately will bear good fruit by producing greater knowledge and improved methods.

K. E. BELL,[8] Peabody, Mass., (WRITTEN): In the development of low temperature clothing for Air Force personnel, it was found that comfort is dependent on many factors. Professor Yaglou's *temperature gradient method* was proved helpful, readily locating breakdown points such as areas compressed by elbows, hips, etc. In such cases temperature gradients readily show weak points and give excellent values (comparative) with different materials and constructions.

[8] Vice president, A. C. Lawrence Leather Co.

Professor Yaglou's presentation makes it clear that the *temperature gradient method* warrants additional subjective studies.

A. C. BURTON,[9] London, Ont., Canada, (WRITTEN): I was very interested to receive a copy of this paper. I have several comments to make as follows:

1. I would plead with Professor Yaglou to alter his nomenclature to conform to what has now been accepted by so many interested in these matters. Although he uses the term *insulation* he uses the symbol R (resistance) for this. Would he please use I as the rest of us now do. I notice that, without explanation, he changes from R to I on page 108.

Again, I wish he could be persuaded to use kilocalories, instead of Btu, kilograms instead of pounds, square meters instead of square feet, and degree Centigrade instead of degree Fahrenheit. I realize the paper is written for the ASHVE and engineers to whom the units he uses are much more familiar, but we have succeeded in getting the physiologists and the administrators of OQMC, etc., to think in cgs units; even the meteorologists in England have gone to degree Centigrade and I do not despair of getting the engineers to do so some day. In this field which is largely physiology, the units he uses are utterly unfamiliar to the physiologists. The equations, using Clo units, are much simpler in this cgs system.

2. On page 108 in the definition of the Clo unit, he omits the very important condition that the man concerned must *be at rest* (heat production 1 Met. or 50 Cal per (sq in.) (hr). This omission might encourage the reader to forget that the heat balance depends just as much on the heat production as on the heat loss.

3. Professor Yaglou's reference to loss of insulation value, due to wetting by perspiration and air pumping action during work, might imply that wetting of clothing is advantageous, whereas, it is the big difficulty we now are tackling. I know Professor Yaglou does not mean this, but it might be so understood.

4. General comment as to the method of Professor Yaglou: I was previously familiar with this ingenious method and thoroughly approve of it in principle. It is interesting to me that it is identical in principle with the method I devised for measuring the thermal insulation (or conductivity) of the peripheral body tissues as long ago as 1934. (However, since LeFevre in 1911 did the same thing I cannot claim much originality.) I also agree with Professor Yaglou as to the limitations of the heat balance method. However, I feel that he does not emphasize some hidden errors in his method that may be equally great. These errors exist because the whole method is based on an accurate knowledge of the value of the insulation of air, I_a. It is all very well to assume a standard value for this, based on the air movement, measured presumably at some distance from the body. But what is the value of I_a in the vicinity of a hand that is swinging with the motion of the body, near the trunk of a man marching at 3 mph on a treadmill in a chamber where the air movement is 5 mph? No one would claim to be able to calculate this. A second factor capable of changing I_a is the curvature of the surface losing heat. When the radius is small, it is impossible to obtain a high value of insulation for this reason. (This factor is well known in the electrical analogue of resistance to current flow, in the well known action of points in discharging a condenser.) This is the basic reason why it is impossible to get more than $1\frac{1}{2}$ to 2 Clo units insulation in a glove. The same factor must change the value of I_a where acute curvatures are concerned. Until these points are elucidated, I do not think Professor Yaglou can be sure that his method possesses greater accuracy.

The inability to calculate accurately heat storage when steady states are not reached in the experiments, applies as well to Professor Yaglou's method as the others, though due to the lower thermal capacities of clothing compared to tissues, the errors will not be as great. I have always pointed out in the heat balance method, which I believe I originated, that good results were obtained only when experiments were done close to steady state conditions, *i.e.* at temperatures where protection by clothing was adequate. Others using the method have tended to forget this precaution.

These criticisms do not alter my opinion that in this discussion Professor Yaglou has made a very valuable contribution to our knowledge in this important field.

[9] Professor of Biophysics, University of Western Ontario.

A. P. GAGGE,[10] Dayton, Ohio, (WRITTEN): In the Aero Medical Laboratory at Wright Field we have had considerable success using a copper manikin and copper hands and feet for evaluating thermal insulation of clothing. Our manikins were all made by the General Electric Co. during the war and have variable segmental imputs for analyzing the Clo value of various flying clothing assemblies. The individual foot and hand manikins have proven to be very useful in studying the insulating value of gloves, mittens, boots, and socks in various experimental combinations. Each of our copper *Clometers* for hands and feet have

[10] Lieut.-Colonel, MSC, Chief, Aero Medical Operations, Aero Medical Laboratory, Engineering Division, Wright-Patterson Air Force Base.

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thermocouples located over various areas so that uniformity of insulation can be evaluated from a knowledge of the heat input, from the local mean skin temperature, and from the air temperature and air movement of the environment. By this method it has been possible to make extremely reliable measurements of clothing insulation, not only for the body as a whole, but for the segmental areas individually.

We do not recommend the use of the copper man and components as a complete substitute for a human in evaluating clothing, but as a first order approximation of the probable physiological effect the manikins have proven very useful in preventing unnecessary and tedious human experimentation. It might be mentioned at this point that the *overall insulation method* is used by our laboratory only on the copper man, and is considered too unreliable and too tedious for human experimentation as pointed out by Professor Yaglou. In Air Force clothing problems the bellows action of clothing in reducing Clo value is not significant as it would be for the marching soldier, since flying personnel are usually at rest during their occupation specialty. For this reason overall insulation values via the copper man are quite significant in critical human clothing experiments in aeromedicine. Professor Yaglou's temperature gradient method is no doubt a very useful approach to the evaluation of local and overall insulation. The success of Professor Yaglou's method lies in his ability to evaluate quantitatively the heat loss from the surface of the clothing by methods of known convection and radiation relations. His resultant accuracy would also imply reliable measurements of outer and inner surface temperature of the garments, and of air movement over the area under consideration. It is questionable whether the local evaluation of clothing insulation has any real significance without a proper overall evaluation for metabolic rate, rectal temperature, body cooling, or heat loss by evaporation.

Professor Yaglou's method is reminiscent of a *Btu meter*, developed by Prof. L. M. K. Boelter at the University of California before the war. This instrument consisted of a thin plastic plate wired with a pile arrangement of thermocouples terminating on each side of the plastic plate. From the observed temperature gradient and the known thermal conductivity of the plastic, it was possible to evaluate at any moment the heat transfer through the plate. Professor Boelter loaned some of these Btu meters to the Aero Medical Laboratory early in the war and they proved to be very useful in measuring localized heat transmission through clothing. The difficulty with these plates was that they were impermeable to moisture and were rather large (4 in. square). Our work at the Aero Medical Laboratory with these plates was unpublished, but I believe Professor Boelter's use of the Btu meters in evaluating heat loss through walls has been published.

A. C. GOODINGS,[11] Toronto, Ont., Canada, (WRITTEN): In the material presented in this paper, Professor Yaglou emphasizes the fact that different parts of the body require different amounts of insulation if the subject is to be uniformly protected against cold; and therefore rightly points out that one should be concerned with methods of measurement of insulation over particular areas. Methods such as the *heat loss method* which study only the overall insulation consequently are of limited value. The following observations will be confined to the more flexible *temperature gradient method* which does not suffer from this particular limitation.

The reliability of results by the *temperature gradient method* depends upon the accuracy with which temperatures at particular points can be measured, coupled with a knowledge of the thermal insulation of the air layer exterior to the clothing. Values of the latter show that the thickness of the layer of *ideal still air* varies widely with wind speed, the change being most rapid with change in wind speed in the low velocity range. At 35 fpm the air layer insulation is equivalent to approximately 0.80 Clo units falling to 0.50 Clo at 120 fpm (1.37 mph), and to 0.20 at 1000 fpm (11.9 mph). Similar values for the thickness of the layer of *ideal still air* have been found at different wind speeds for the resistance offered by the external air to water vapor diffusion through clothing. To use a value for the insulating effect of an external air layer, the conditions of air movement or wind speed past the clothing must therefore be known with considerable precision.

Accepting the accuracy of these values, however, a more serious difficulty arises in connection with the measurement of the necessary temperatures, in particular the measurement of temperature at the outer surface of the clothing under evaluation. The temperature required is that in the surface which marks the boundary between the fabric and the external air, that is the plane of demarcation between where the insulating effect of the fabric ends and the insulating effect of the external air begins. This boundary is obviously ill-defined, particularly when wool or fabrics having a napped or loosely fibrous surface are under consideration. Lack of definition in the position at which the temperature is taken can, however, be very serious. For example, consider clothing equivalent to 2 Clo units under test in the air moving at 50 fpm. The thermal insulation of the external air layer would be equivalent to 0.70 Clo units. But 1 Clo unit is equivalent to 0.53 cm (approx. 0.21 in.) thickness of ideal still air, and the clothing can therefore be thought of as a layer of air 2 x 0.53 = 1.06 cm (0.417 in.) thick, and the insulation of the external air as equal to a layer of ideal still air 0.70 x 0.53 = 0.37 cm (0.146) thick. The total insulation is therefore equivalent to 1.06 + 0.37 = 1.43 cm (0.562 or 9/16 in. of *ideal still air*). The calculation of the insulation by the *temperature gradient method* depends essentially upon multiplying an air insulation value by a factor which is a ratio of two temperature differences, and this latter can be represented by inverse air thicknesses. This ratio in the present example is given by $\frac{1.06}{0.37}$ which is 2.9 (approx.). If, however, the temperature were measured at a point which was equivalent to an error in surface level of 1 mm, then the foregoing ratio would become distorted due to a 1 mm error in the numerator and similar error in the opposite direction in the denominator. In the case under consideration this would make the ratio $\frac{0.96}{0.47} = 2.0$ (approx.). The multiplying factor is then in error by $\frac{2.9 - 2.0}{2.9} \times 100 = 31$ percent, and therefore the insulation value calculated for the clothing would also be in error to this extent. Similarly, for an error in surface level (at which the temperature was recorded) of 0.5 mm the percentage error in the result would be 17 percent. It is clear, therefore, that the accuracy of the result is highly dependent upon the accuracy with which the temperature value (obtained experimentally) records the temperature at the boundary between fabric surface and external air. The difficulties in defining this boundary and therefore in the placing of temperature measuring equipment in this boundary plane are obvious. Because also, it is temperature at a point on a line perpendicular to the clothing which is required, the use of thermocouples may be held open to criticism as well as methods of attaching and covering, for example, with adhesive tape. If the attaching of the thermocouples to the fabric surface gave rise to positioning slightly too far out from the true boundary (which is probable) an error of 10 to 30 percent, quoted by Professor Yaglou, as the difference in ratings obtained by the *heat loss* and *temperature gradient methods*, the latter being the lower, might easily be expected.

It would appear that some less direct method than that outlined in the *temperature gradient* procedure which would obviate the necessity for accurate temperature measurement at a visually ill-defined boundary would be necessary to obtain accurate and reliable results.

[11] Director of Textile Research, Ontario Research Foundation.

Somewhat similar problems have been encountered in connection with the measurement of the resistance of fabrics to the passage of water vapor where vapor pressures could not be measured directly at a fabric surface. The problem of measuring the thermal insulation is considerably complicated by the desirability of measuring the value for clothing as worn on the body. Professor Yaglou in his paper points out the severe limitations and present unsatisfactory state of existing methods of measurement in connection with a very important practical consideration.

DR. MILTON HARRIS,[12] Washington, D. C., (WRITTEN): The overall *heat loss method* includes loss from the face, if this is exposed; this should make the clothing insulation appear smaller than in reality. However, estimates by the overall method appear to exceed estimates by the *temperature gradient method*, so there must be other even greater differences between the methods.

A technique in which the temperature over larger areas is automatically averaged by using a resistance thermometer (the wires of which form a grid over the area in question), might improve the precision of temperature measurements at clothing surfaces. Such a technique has been used by Prof. H. C. Bazett at the University of Pennsylvania.

Since the *temperature gradient method* depends on knowing the gradient across one layer of known insulating value, it might be improved by using the insulating value of a fabric layer rather than that of the outer air layer as the reference standard. The insulating value of a fabric layer can be determined by hot plate methods, if attention is given to the resistance of air layers included in the measuring system. The accuracy would then depend on the measurement of surface temperatures on each side of this fabric layer.

Since in clothing there might always be some air layers included with the fabric, it might be still better to make successive experiments using two different fabrics of similar structure but different thickness and insulating value, and use this difference of insulating value as the reference resistance. Another procedure would be to use the increment of insulation in a series with one, two, and three layers of fabric as the reference standard. This would require separate measurement, by the hot plate or cylinder method, of the successive layers; with care that the air space between fabrics was the same during these measurements as during the clothing experiments.

A hopeful indication for the possibility of the use of fabric as a standard is the observation that differences in fabric insulating value of the order of 0.01 Clo can be recognized subjectively.

L. H. NEWBURGH, M.D., Ann Arbor, Mich., (WRITTEN): Professor Yaglou has restricted his presentation to the consideration of clothing as protection against cold. I will remain strictly within the same field.

It is a simple matter to determine the thermal resistance of textiles used in the construction of clothing. However, such information falls far short of giving a satisfactory answer to the question, how much and what kind of clothing will permit comfort under any given environmental circumstances? This is so for a number of reasons: (1) the heat transfer is affected by the moisture content of the textile, (2) varying degrees of compression change the thermal resistance of the material, and (3) heat escapes through the various openings in the clothing and from the head, a part of which at least, is completely exposed.

Many students have tried to answer the problem satisfactorily by measuring the loss of heat from a man wearing different amounts and types of clothing. While this procedure has given valuable information, it is far from successful because the main point to be settled is how to dress the individual so that he will be comfortable. The difference between what seems to be adequate from the purely physical point of view, and what may be required in order to satisfy the individual, is often great. This is primarily the case because heat is not lost uniformly from the body surface per unit area. The loss of heat may be far different over the extremities from that over the trunk. In order to lessen the total loss of heat, the blood may be very largely shut off from the integument of the extremities, especially the hands and feet. Consequently, their surface temperatures decline strikingly and approach that of the environment. On the other hand, the surface temperature over the trunk, under these same circumstances, falls only slightly, and hence there may be a large loss of heat from that region. The cooling of extremities when the temperature reaches a certain degree is uncomfortable or painful and may be so painful as to incapacitate a part or the whole individual so that while the loss of heat from the hands and feet may be almost negligible, and thus lessen greatly the total loss of heat from the organism, the result from the point of view of the whole man may be distinctly undesirable, or may even cause serious injury to the extremities. For these reasons, the second method, the one which measures the loss of heat from the whole organism under cold conditions cannot decide whether the clothing is adequate. The colder the environment, the more is this the case. It has been shown that in the presence of very low air temperatures it is impossible to produce a glove that is capable of keeping the fingers warm enough to function. This is so because as the insulation of small cylinders increases, its effectiveness decreases very rapidly and eventually a place is reached at which further layers actually cause increasing rate of heat loss, so that while the trunk may be comfortable the hands can become completely functionless. This condition can be met in one of two ways: the hands can be enclosed in sufficiently thick mittens and so prevent excessive cooling, or electrically heated gloves can be worn. In the first case, the protection is so awkward that the hands become nearly functionless for finer movements.

Professor Yaglou has presented a technique for measuring the heat loss across the clothing over various parts of the body, and has shown how it varies from place to place. It seems clear that such a technique must be employed since it is clearly necessary to consider many individual areas of the body in order to provide adequate insulation in a regional manner.

H. B. NOTTAGE, Cleveland, Ohio, (WRITTEN): Since this paper is primarily a review of other published material, it is suggested that this be indicated by the summary and title. Where did Tables 2, 3, and 4 come from?

Can the *comfort*, which it is desired to attain, be defined in quantitative, physically-measurable terms? If psychological or physiological factors are involved, then is it not proper to use statistical terminology in reporting the results? This would avoid unsafe reliance upon *exact* numbers and introduce pertinent data on the standard deviation of the results, the statistically important features of the persons used as subjects, and the like.

The invention of the Clo unit appears to be quite unnecessary if, as given in the paper, this unit is then merely redefined in terms of a fixed numerical heat transfer magnitude. At any rate, how can a unit be established to measure something which, as brought out in the paper, is itself not yet understood? Moreover, without going into details, it appears that the entire treatment of heat transfer phenomena has not been adequately grasped by those who have contributed to the information presented.

If this paper is representative of the state of knowledge concerning heat and moisture transfer and air filtration through clothing, then the reason becomes quite apparent as to why the author has reported that *the whole field is wide open to new ideas and techniques*. Investigators thus far, recognizedly in great need of some sort of information which would have an immediate utilitarian value, have attempted to lump everything together and to *solve* all problems in terms of some single factor. As the author himself implies, this is *not* the way to obtain reliable fundamental data of a permanent *scientific* value. Instead, it is high time that the entire, complicated, composite system, body-clothing-surroundings, should be broken down into constituent parts which are individually of

[12] Harris Research Laboratory.

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a sufficiently limited scope to permit thorough and profitable *analysis*, bit by bit. Then, once the characteristics of the complete system can be satisfactorily synthesized from those of its constituent parts, true fundamental progress will have been made. Is there not a common meeting ground in this sort of thing where the *research engineer* can take his rightful place as part of a group who would really work towards the roots of the clothing problem?

SID ROBINSON,[13] Bloomington, Ind., (WRITTEN): Professor Yaglou has made a definite contribution to the field in developing the *temperature gradient method* for evaluating insulation of clothing. Its greatest value is that it makes possible the determination of insulation of local areas of clothing. It should be helpful in designing cold weather clothing with ideally distributed insulation. In developing electrically heated clothing this method should be helpful in determining the proper distribution of the heat supply in relation to insulation. In designing clothing for protection of men in extreme cold, however, the overall metabolic responses as well as the cutaneous circulatory responses must also be taken into account. For instance, Bazett and Burton found during the war that locally heating the hands and feet of men wearing arctic clothing in a cold environment may cause a general vasodilation and a general loss of heat with lowered rectal temperature. Thus, although the hands and feet of men exposed to cold, cool more rapidly than other skin areas and are more apt to freeze, we must consider the whole organism in providing the best protection for them.

I should like to ask a question concerning the effects of moisture in cold weather clothing. Professor Yaglou states that *with subjects at work, cold weather clothing may lose much of its insulation due to wetting with perspiration*. . . . Is the loss of insulation, due to wetting, as important physiologically as the cooling effect of evaporating the moisture from the inner layers of clothing during the post-work period?

PAUL A. SIPLE,[14] Ph.D., Washington, D. C., (WRITTEN): This whole subject was highly debated at the recent meetings in Canada and much new information is being collected continuously. Professor Yaglou's paper is a scholarly statement of facts as they appear to him today, but undoubtedly will be revised by others in the not too distant future. Of the two systems of calculating insulation, the newer one that he presented which shows higher insulation values by 10 to 30 percent is partially explainable by the fact that his method does not consider heat loss, due to uncovered parts of the body, such as face and hands. The Clo method of determination takes the body as a whole and averages off the losses of exposed parts making the clothing appear to be less valuable than it really is. The only technical criticism that I have is that Professor Yaglou forgot to point out this discrepancy. This discrepancy happens to amount to about the difference, and therefore in final analysis, the two methods would prove to check closely. A third method which Professor Yaglou may not be acquainted with (although I am quite certain I have discussed it with him) involves a simple method of measuring the increase of clothing thickness over parts of the body in which the insulation thickness of included dead air and clothing are given physical values. I have found that by this method I could estimate clothing insulation very close to the values determined by calorimetric methods, and at the same time, I could evaluate the clothing value at each layer and analyze the fit of the garments. In view of the fact that this method is dependent basically on factors previously determined by other methods and that it does not involve temperature measurements, it appears to be less scientific; though from a practical aspect, I have found it the most useful method to date.

C.-E. A. WINSLOW, New Haven, Conn., (WRITTEN): There is no conflict between the *heat loss method* of estimating overall insulation of clothing developed from a suggestion by Gagge, Burton, and Bazett, and the *temperature gradient method* presented by Professor Yaglou.

In a numerical sense insulation values determined by the two methods will be different due to the assumption that all nonevaporative heat loss passes through the clothing gradient in one case, and the computation of this transferred heat from gradients in the other case.

Aside from this acknowledged systematic error in the *heat loss method*, the accuracy of either method as a measure of clothing insulation is seriously conditioned by the values assumed for air and radiation insulation at the outer surface.

The two methods are logically complementary. The most desirable method would use the gradient technique for two purposes: (1) to determine the fraction of heat production which bypasses the series insulation of the clothing through exercise-induced *bellows action*, and (2) to analyze the local deficiencies in insulation in clothing assemblies.

For quick estimation of comparative overall clothing insulation on heated manikins, the *heat loss method* is quite satisfactory and in reality reduces to a single gradient method supplemented by direct information on heat input. When this heat input is corrected for parallel heat loss from unclothed areas using the same constants that the *temperature gradient method* must apply to the entire surface, the difference between the two techniques should not be significant.

Professor Yaglou emphasizes in a constructive manner, the utility of local gradients for the analysis of local insulation, and the present need for a refinement of the Clo concept to take account of the previously neglected parallel heat losses. Studies requiring detailed information will, of necessity, utilize a combination of the two methods.

L. E. SEELEY, Durham, N. H.: Certain shortcomings of the manufacturers of men's clothing, from a comfort and health point of view, remind me of something which I read a long time ago to the effect that the most important item of clothing for the soldiers in the armies of Napoleon was a broad flannel belt wrapped around the middle of the body. It was believed that adequate protection of this part of the body would permit soldiers to be exposed to severe weather conditions without harm to their health. The thought was to protect the *vital organs*.

AUTHOR'S CLOSURE: Some of the points raised are, I believe, adequately discussed in the paper; others apparently have not been stressed enough, in the light of Burton's and Bazett's comments. This seems to be the case, particularly with the insulation of air, I_a, which is indeed a weak link in both the heat loss and temperature gradient method. In subjects resting in still air, the error is not great, when we deal with insulation of a uniform, but may become considerable in high winds, particularly when the items tested are gloves or boots. I_a will then have to be determined by special physical tests in which the heated gloves or boots are exposed to simulated test conditions, as was done in our studies of boot insulation (Table 4).

There will be no correct answer until we learn how to determine accurately the instantaneous body heat debt, or gain, by tests such as those planned by Benzinger. If we succeed in this, we can eliminate I_a by combining the two methods now in use, or by developing some better method. Here is a chance for Nottage in a field that is wide open, where no license is required to get in.

The paper is not altogether a review of published material. Although the heat loss method was published in *Science*, the temperature gradient method never appeared in the open literature before. Table 4 contains original unpublished data; Tables 2 and 3 on pile fabric uniforms, I believe, are from a confidential report to the Quartermaster, also unpublished; while Table 1 shows application of the method to some old observations we made in 1939-1940.

[13] Professor of Physiology, Indiana University.

[14] Bio-Geographer, Research and Development Division, Office of Chief of Staff, War Department.

Sanitary Significance of Ventilation

By William F. Wells*, Philadelphia, Pa.

SUMMARY—The author points out that the old theory, that spray-borne disease is not likely to be air-borne, has been disproved. It is now known that as droplets carrying disease germs evaporate in the atmosphere virulent nuclei are formed. These drift around in the room air until inhaled, vented or destroyed. In some of the experiments conducted by the author he has found that by use of ultra-violet irradiation of the air in the upper part of the room he has accomplished as much removal of bacteria as would be accomplished by 69 air changes per hour. In other tests he doubled the irradiation and accomplished as much bacteria removal as would be obtained with 116 air changes.

Such enormous air changes, even if economically feasible, could obviously not be used in air conditioning practice because of extremely high velocities and drafts they would produce. Hence, irradiation in the upper part of a room is recommended as a means of obtaining the necessary disinfection without use of excessive outdoor air quantities. The author describes methods of testing the spread of infection in a room and also the method of measuring the disinfecting properties of ultra-violet radiation. He explains that *E. coli* is used as the infecting bacterium because it is harmless, easy to grow, and is not a normal inhabitant of the air. Its characteristics have been fully established and simple bacteriological methods of isolation and identification have been worked out. Other reasons for its use are given in the paper.

DURING an average American lifetime, a human being breathes several million cubic feet of air. Of this enormous total more than 1,000,000 cu ft of confined air shared by other persons are breathed indoors. There are many kinds of germs in this air and, while most of them are harmless, the fact remains that infected persons expel into the atmosphere droplets which evaporate at once, and leave virulent nuclei that drift about in any confined space until inhaled, vented or destroyed. The demonstration of this fact refuted the prevailing bacteriological theory that because a disease may be spray-borne for only some three feet, it is not likely to be air-borne.

The hazard of breathing disease germs in outside air is practically negligible. The enormous dilution of infection in the vast expanse of the atmosphere and the exposure to germicidal sunlight leaves but an infinitesimal chance that a person will breathe these virulent nuclei remaining from droplets expelled by others. During the summer when people live outdoors more, or when, because of open windows and doors, the air breathed indoors mingles freely with outdoor air, respiratory diseases decline. It is during the winter, when people crowd into tightly closed rooms to keep warm that air-borne contagions become epidemic. The mortality peak that used to come in summer before water and food sanitation cut down intestinal infection now comes in the winter, the season of respiratory infection. It is indeed fortunate that the conditions conducive to air-borne infection are the very conditions that are most favorable for effective radiant disinfection. These conditions are: (1) indoor air is dry during the winter, (2) irradiation is entirely independent of windows and doors, whether closed or opened, (3) selected places can be irradiated, or can be shielded from radiation, and (4) irradiation, being self-regulatory, requires only good designing and clean lamps for proper operation.

Bacteriology cannot possibly hope to apprehend and lay hold of the specific organisms in the enormous volumes of air involved in the spread of an epidemic. Even in the laboratory, under controlled conditions of experimental ventilation, where all animals can be infected within a few minutes with a high concentration of disease organisms, many of these organisms are very difficult to isolate and identify. One thing is sure, the merest fractions of the concentrations used in the laboratory would, under natural conditions of infection, produce devastating epidemics. People are the most sensitive air samplers and their reactions to the air they breathe are therefore the final test of air purity. Nevertheless if sanitary ventilation is defined as the reciprocal of the existing chance that a pathogenic organism expelled into the atmosphere will be breathed by another person, the quantitative results of laboratory experiments can be interpreted into terms of such ventilation.

Obviously, the fraction of the enclosed atmosphere inhaled represents the chance that an organism may be breathed in the first breath. By the second breath, the chance is just so much reduced by the possibility that the organism was breathed in the first breath, and so

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on for succeeding breaths. This fraction being small, the hazard, h, can be expressed by Poisson's law of small chances as:

$$h = e^{-\frac{v}{V}} \quad \ldots\ldots\ldots\ldots (1)$$

where

e = Naperian base of logarithms 2.718
v = volume breathed
V = volume of space

Since the likelihood of inhaling infection is equal for all the occupants of an enclosed space, it follows that, the more occupants there are, the smaller is the likelihood for each occupant breathing a particular organism. Similarly, the likelihood is reduced by the chance that the organism may be removed from the enclosed space by ventilation. At each moment, the chance of breathing or venting the organism is proportional to the breathing or ventilation rate respectively, and the hazard of infection by the organism is correspondingly reduced. The chance of venting an organism then becomes:

$$h = e^{-A} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where

A = number of air changes

Formulations for the hazard of infection are simplified if expressed in terms of ventilation per occupant. For example, in a standard classroom supplied with 30 cfm per pupil, the chance that an organism will be vented in the first minute, is 150 times the hazard that it will be breathed in that minute. In succeeding time intervals, the logarithms of the chances of breathing or venting the organism are in that same ratio. Since air disinfection can also be expressed in terms of Poisson's law as

$$h = e^{-L} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where

L = a lethe of disinfection, the sanitary equivalent of (and interchangeable with) one air change

It may be convenient to adopt the cubic-foot-lethe as a unit of bacterial reduction equivalent to ventilation by a cubic foot of pure air.

Method of Measuring Sanitary Ventilation

The rate of removal of standard test organisms from confined atmospheres equivalent to venting by pure air replacement can easily be determined by bacteriologic technique of sanitary air analysis as follows:

An atomizer sprays a continuous mist containing the test organisms; the finely divided droplets evaporate instantaneously in the dry indoor air during the winter, leaving the test organisms suspended in droplet nuclei as an invisible aerosol which disperses like cigarette smoke throughout the room on air currents. Although small scale humidifiers were first adapted to this technique the Fragrant-mist vaporizer has proved to be most convenient and dependable. A single instrument is capable of building up a satisfactory aerosol cloud of test organisms in about 2000 cu ft of air; one instrument at breathing level in each quadrant of a schoolroom will disperse a uniform cloud throughout the room simulating average conditions of infection by pupils. The air centrifuge in the center of the room samples or *breathes* the average *infection* from the four quadrants.

If constant numbers of organisms are added to an enclosed atmosphere and constant volumes are sampled in equal time intervals, the relative numbers when equilibria are reached under different conditions of ventilation will then be proportional to the rates of elimination by ventilation. If ventilation is then determined by the die-away rate when the atomizers are turned off, any change in ventilation can be evaluated from the ratio of the concentrations when equilibria have been reached. Thus the test becomes the measure of the hazard of infection to an infectee at any point resulting from an infector at some other point in an enclosed space under given conditions of ventilation.

It should be emphasized that the measurement of sanitary ventilation in terms of such a standard method merely defines ventilation with respect to a particular organism in a particular state of atmospheric suspension due to any particular disinfecting procedure. *E. coli* is selected as the test organism because of the exhaustive study given to this organism in sanitary science; its characteristics are fully established and simple bacteriological methods of isolation and identification have been worked out. Since *E. coli* is not a normal inhabitant of the atmosphere, selective media which inhibit other common dust-borne organisms (contaminants in this test) make it possible to state definitely that the organisms recovered from the air were put there by the atomizer, a highly important feature from the standpoint of conclusions drawn from a test.

There are also many other good reasons for using *E. coli;* it is harmless, hardy, and easy to grow. Almost all coefficients of disinfection are in terms of *E. coli* or its first cousin, the typhoid organism. Of special importance in sanitary ventilation is the exhaustive study of the vulnerability of *E. coli* to ultraviolet light; no organism has attracted more attention in the study of bactericidal irradiation of liquids, moist agar surfaces, or humid or dry air. Moreover the vulnerability in air of various significant organisms relative to *E. coli* has been carefully evaluated. Each bacterium therefore becomes a tiny photometer drifting at random on air currents like a balloon-carried instrument; the average sample therefore truly measures air circulation in ventilation.

In a standard routine test of a typically irradiated schoolroom, for example, 20 min are allowed, after atomizers are started in each quadrant, to build up an equilibrium concentration. Then three consecutive five-minute samples, at one minute intervals, are collected from the center of the room. Next, ventilation is changed, (*i.e.* the lights may be turned off), and 20 min are allowed for a new equilibrium to be established, whereupon three more consecutive samples are collected. This cycle may be repeated with as many variations of ventilation as desired. Lastly the atomizers are turned off, and three more consecutive samples are taken immediately

to determine the die-away rate. Sanitary ventilation in lethes, or equivalent ventilation by an uncontaminated air supply, is then obtained by multiplying the die-away rate, expressed as air changes, by the ratios of the equilibrium concentrations[1].

Lethal Exposure[2]

In early studies of schoolrooms, an atomizer was located three-quarters of the distance from the center of the room to one corner; and an air centrifuge was located in a similar position in relation to the adjacent corner. A small household fan blew an air stream over the atomizer, parallel to the diagonal of the long wall, to mix the air and impart a gentle circulation around the three sides of the room to the sampling corner. While, naturally, the disinfection values varied with the direction of air circulation from infector to infectee, through the irradiated zone the average of 16 tests in centrally lighted, square classrooms of about 6000 cu ft, irradiated with approximately 4 ft watts, yielded a sanitary equivalent of 69 air changes per hour or approximately 10 times as much disinfection as would be obtained by normal winter ventilation. Doubling the amount of radiation from each fixture resulted in increasing the average (of 9 tests) to 116 equivalent air changes per hour. The primary purpose of the study was to demonstrate the value of the method as a means of correlating clinical experience with sanitary ventilation by air disinfection. This was accomplished, together with a demonstration of potential elimination (by means of sanitary ventilation) of air-borne infection during the winter comparable to that obtained by summer ventilation, when respiratory diseases decline markedly.

In the third year of experimental studies, when supplementary irradiation required retesting, an attempt was made to compensate for directional circulation. The infector and infectee were located on a room diagonal, about halfway from the center to opposite corners of the room. Tests were run in these positions and duplicated for reversed positions. A general average of 142 lethes, or equivalent air changes per hour, was obtained from 17 such duplicate tests in the different rooms. The fact that in each pair of tests the average of the larger was four times the average of the smaller indicated the need of further study of disinfection gradients between various points in the rooms before a more stable method of evaluating the performance of fixture designs could be devised.

Lethal Gradients[2]

Disinfection gradients in sanitary ventilation were obtained in schoolrooms. Simultaneously samples were taken in the different corners of a rectangular room equipped with end wall fixtures. The lethal exposures in a series of 17 experiments were averaged on Fig. 1 (upper). The values shown in Fig. 1 indicate the number of room air changes which would be required to effect the same reduction in air disinfection. As the air circulated from the infector around the room the number of bacteria decreased progressively, being in the third sampling corner about one-half what it was in the first. In the average of 12 runs in the centrally

[1] Exponent numerals refer to References.

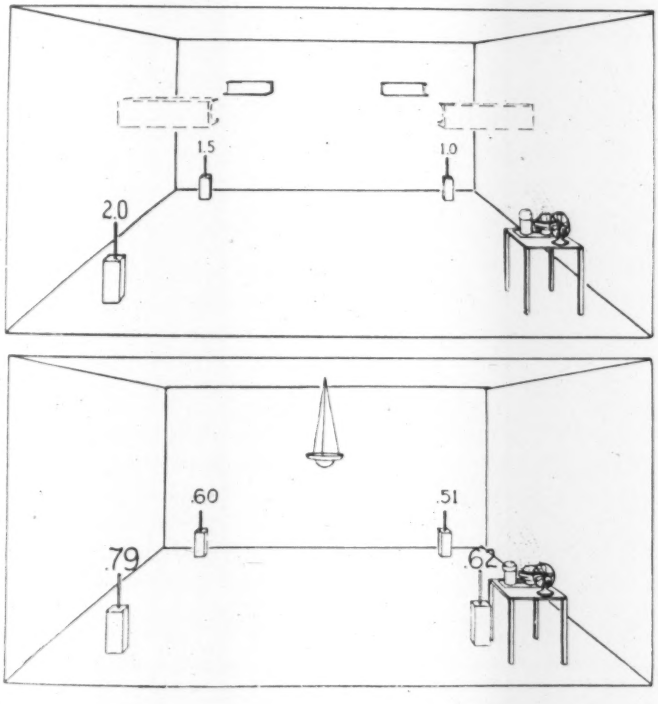

Fig. 1—Lethal exposure of organisms atomized into one corner, and sampled at the other corners of irradiated classroom

Values represent air changes per minute which would accomplish equivalent reduction in the room

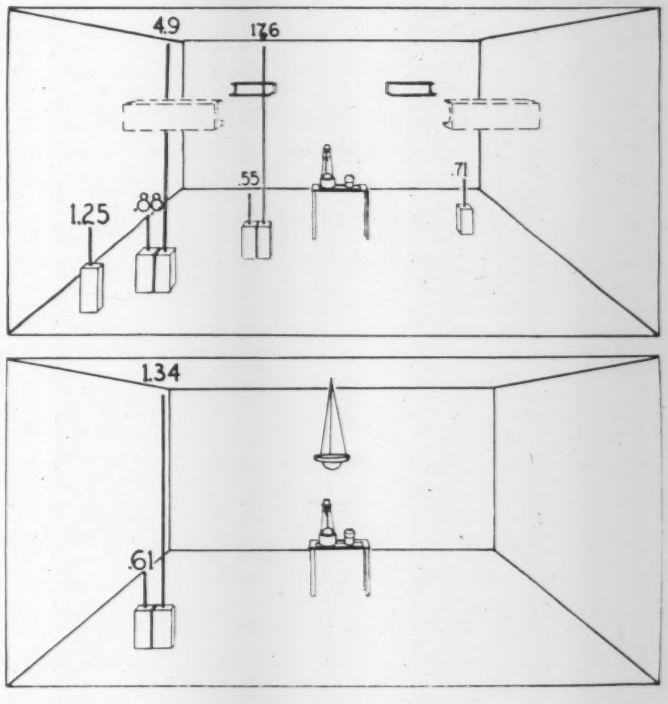

Fig. 2—Lethal exposure of organisms atomized into center, and sampled at different distances and elevations of rooms shown in Fig. 1

Values represent air changes per minute which would accomplish equivalent reduction in the room

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lighted square room (Fig. 1, lower) the effect was less pronounced; probably because the lethal gradient depended more upon dilution with the irradiated atmosphere from the core of the room, than upon direct circulation through the irradiation. Local mixing might also be indicated by the lower value obtained in the corner near the infector. The value obtained in the corner opposite the infector approximated the average in the first and third corner in both sets of experiments. Since this more representative test of average disinfection was about three-quarters of that obtained by the method used in the original experiments, the average results can readily be converted.

In a second series of experiments, with the infector located in the center of the room, a small fan, with housing removed and supported on a tripod above the atomizer, was used to distribute the infected air in a horizontal direction. Samples were collected one-third, two-thirds and five-sixths of the distance from the center, at the middle of the long side, and also one foot below the ceiling at the first two stations. The average reduction in bacteria from 81 runs in the rectangular room, expressed in lethes on Fig. 2 (upper), is considerably lower than in the first series (Fig. 1) but increases progressively at working level with distance from the infector. Organisms collected from the upper air of the rooms were many times more heavily exposed than those sampled at working level, and the gradient was reversed. The greater reduction in bacteria farther away from the light would seem to indicate circulation toward the wall at working level and in reverse direction above.

Several factors could account for differences between these two methods shown in Figs. 1 and 2. Perhaps natural circulation between the chosen testing points (Fig. 2) was actually lower; but the small fan might also make a difference. Slight stratification by the mushrooming of air, cooled by evaporation of infected droplets, was shown in 24 runs by an increase of 30 percent in reduction of organisms when a small heating element was suspended beneath the fan. Body warmth of occupants might similarly influence bacterial reduction by increasing circulation.

Samples taken at a point two-thirds of the distance from the infector to the corner of the square room with the central hanging fixture compared more favorably with those taken by the previous method. The averages of 24 runs are shown in Fig. 2 (lower). Exposure to irradiation of organisms sampled in the upper level was hardly more than double that at the lower level —contrasting sharply with the large differences observed in the room with end wall radiation fixtures. These observations would also seem to indicate more effective circulation through the irradiated core of the square room than through the more remote angles between the ceilings and the walls in the rectangular room.

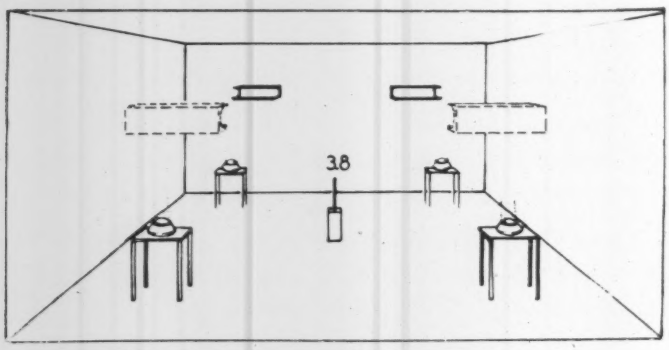

Fig. 3—Average lethal exposure of organisms atomized into four quadrants and sampled at center of room

Values represent air changes per minute which would accomplish equivalent reduction in the room. (low visored beam angle as in upper diagram, Fig. 1)

Average Lethal Exposure[2]

A lethal gradient L_a, theoretically represents a statistical average of reduction of organisms passing on an infinity of paths from infector to infectee. The test actually gives a bacteriological average of the reduction of a large number of organisms carried on prevailing currents. The tests vary because of fluctuations in air circulation between fixed points. These fluctuations must also be averaged if a gradient is used as an index of sanitary ventilation.

Average lethal exposure, L, of organisms circulating from an occupied through an irradiated zone theoretically represents a statistical average of an infinity of gradients between occupants of a room. The average gradient derived in these studies was only 58 percent of the lethal gradient previously used as an index of sanitary ventilation.

Gradients from a number of infectors to a single sampling point can also be averaged bacteriologically in a method by which average lethal exposure of test organisms atomized into four quadrants of a room is measured at the center (see Fig. 3). By compensating for directional circulation, the test averages disinfection gradients. The organisms are dispersed, with a minimum of atmospheric stratification, or disturbance, from crowns of little orifices in small vaporizers. In a series of nine comparative tests conducted the average lethal exposure obtained by this method was 60 percent of lethal gradient formerly used as a standard of sanitary ventilation, or about 3 percent higher than the average lethal gradient. This method is an improvement which simplifies the measurement of sanitary ventilation (Fig. 3).

Sanitary Ventilation by Chemical Disinfection

Tedious scientific experiments in sanitary ventilation were required to establish droplet nuclei contagion by a process of elimination by means of radiant disinfection. Similar analysis will become necessary in demonstrating the effect of sanitary ventilation by chemical disinfection with hygroscopic vapors. It should not be assumed, as has sometimes been found convenient, that variations in lethal vapor con-

centrations are non-existent in practice. Uniform vapor saturation, required for effective disinfection, cannot be maintained, either in time or space, amid fluctuating temperatures and humidities of habited atmospheres.

One purpose of heating and ventilation is to maintain comfortable temperatures indoors when outdoor air is cold. Steep temperature gradients make uniform saturation of vapor impossible, and cause inevitable variations in lethal exposure of organisms added at one point, to vapor added at another. For instance, concentrations saturated at the working level would be subsaturated in the upper part of the room, where the temperature might be several degrees higher. Saturation in upper part of the room would mean supersaturation below. Puck[3] has shown that the problem is still further complicated by the fact that saturation of hygroscopic vapor is complementary to saturation with water vapor. Therefore, the lethal concentration of the vapor varies not only with temperature, but also indirectly with variations in relative humidity at differing temperatures. Moreover, condensation upon cold window panes and other surfaces obviously lowers the concentration in the room atmosphere. Without evaluation of these factors, it is impossible to apply laboratory results on chemical disinfection directly to sanitary ventilation. The integration of lethal exposure of standard test organisms, drifting on air currents from one point to another, is the straightforward method of evaluating chemical, as well as physical, disinfection in sanitary ventilation.

Propagation of Infection in Time[4]

Up to this point, consideration has been given only to the elimination by sanitary ventilation of organisms constantly added to an enclosed atmosphere. Measurement of the addition rate of infection upon which the equilibrium concentration equally depends, at first would seem to be an independent problem. In view of the difficulties of isolating and identifying pathogenic organisms in natural atmospheres simple formulation might seem not too encouraging. On the contrary, however, deeper analysis of the dynamics of droplet nuclei infection discloses an implicit relationship: the infectees of one generation become the infectors of the next. Thus, the spread of contagious epidemics through enclosed atmospheres vitiated by the nuclei of droplets expelled by the occupants becomes a true chain reaction to be controlled by sanitary ventilation[4].

For theoretical epidemics in groups of like nature, similarly exposed, there has been mathematical expression of the autocatalytic nature of contagion, the power to grow like fire by its own activity. Thus Wilson and Worcester[5] state that:

Almost all workers in the analytical theory of epidemics assume that the rate at which an infection passes in a population is proportional jointly to the product of the number of persons, I, who are infectious and the number of persons, S, who are susceptible to the infection.

This is called the law of mass action and may be written:

$$C = rIS \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

where

C = rate of new infections
r = a constant, the effective contact rate
I = number of persons who are infectious
S = number of persons who are susceptible

Effective Contact Rate[4]

Every mother learns to expect all her children, who have not yet had measles, to come down with the disease within two weeks after one brings it home. In Providence, R. I., Chapin[6] found 80 to 90 percent of susceptible young children caught measles from a sick brother or sister. Epidemiologists have generally confirmed this secondary attack rate, which they regard as a characteristic of contagious diseases of childhood. But if the effective contact rate represents the static dissemination of the virus in space it also becomes a characteristic of the home.

Only about one in 10 susceptible classmates on the average takes the disease from a pupil coming down with measles while attending class. As compared with the high secondary attack rate in the home this effective contact rate of 10 percent in the classroom may seem unimpressive. But it represents only the static spread of the disease in the first generation; school children usually attend classes until symptoms appear and by re-exposing the class give rise to a second generation. This linkage of cases in one generation to infectors of the next forges chains of successive generations of infection.

Consider, for instance, the chain of generations for a 10 percent effective contact rate when a member of a class containing 20 susceptible pupils comes down with measles. Among the 19 remaining susceptible classmates it would be expected that two would contact the disease within the next two weeks; these would re-expose the remaining 17, giving rise to three more cases in the second generation. Exposure of the 14 susceptible pupils to three cases should yield five cases in the third generation, four in the next, two in the fifth, and the epidemic would end with a single case in the sixth generation; two susceptible pupils escaping infection. Seventeen cases among the 19 exposed susceptible pupils gives a total attack rate of almost 90 percent or about equal to the secondary attack rate in the home. But in the home they resulted from an 80 or 90 percent effective contact rate in the first generation. This intensive static dissemination of infection in space accomplished in one generation what required six generations of propagation of contagion in time with an effective contact rate of 10 percent in the schoolroom.

With less than 10 susceptible pupils per classroom it would not be expected that on the average one would catch the disease from a classmate coming down with measles; by scattering the susceptible pupils through classes who have had measles the epidemic cannot propagate in time[4]. Obviously, while cases exceed infectors, rS is greater than unity and generations are growing, reach a *steady state* at the peak of the epidemic when $rS_T = 1$, and decline when infectors exceed cases, or rS falls below unity. The *density* of susceptible persons, S_T, at the epidemic peak, or the re-

ciprocal of the effective contact rate, is called the *threshold,* because if this *density* is not maintained by accession of persons susceptible to the disease, as when contagion becomes endemic, cases are sporadic and the disease dies out.

Sanitary Ventilation[4]

The amount of infected air breathed in a given time by susceptible persons is proportional to S (the number of susceptible persons); the amount of droplet nuclei infection contributed to the air by the previous generation of cases to I (the number of cases); and the dilution of infection afforded by ventilation to r, or to the reciprocal of V_1S, where V_1 represents ventilation per susceptible occupant. Since rS_T becomes unity at *threshold density of susceptibles,* ventilation per susceptible occupant at this *density,* V_T, becomes the natural sanitary unit of ventilation. The law of mass action, as applied to air-borne contagion, then becomes:

$$C = \frac{IV_T}{V_1}$$

and in terms of V_T as the sanitary unit of ventilation the formula for sanitary ventilation reduces to:

$$V_1 = \frac{I}{C}$$

or the reciprocal of the effective contact rate. Only below threshold ventilation, or when V_1 is less than V_T, can droplet nuclei contagion become epidemic; cases are sporadic when V_1 exceeds V_T, and the infection dies out.

Threshold Sanitary Ventilation[2]

There remains then only the hygienic specification of sanitary ventilation which is a more ambitious problem. Yet, within a decade, medical opinion has abandoned the conviction that air could be but an insignificant vehicle of infection, in favor of a theory that the indoor air we breathe accounts for much of our respiratory illness during the winter. Summer ventilation, on the contrary, will not support contagious epidemics[7]. The maximum ventilation capable of maintaining infection introduced into aggregations of susceptible individuals is threshold sanitary ventilation—the minimum hygienic specification.

Studies of the dynamic spread of contagion in classrooms[5] suggest a threshold of about five times normal winter ventilation (*i.e.* about 5 x 30 cfm per pupil), theoretically attainable by one foot watt of irradiation per pupil with the efficiency of disinfection determined in these studies. Considering how sensitive radiant disinfection is to moisture, and also in view of the practical exigencies of sanitary ventilation and the uncertain values assumed in the theory, as well as the low cost of irradiation, good engineering dictates the fullest practicable utilization of available natural circulation. Table 1 condenses and interprets the results of these studies of sanitary ventilation which checked the dynamic spread of epidemic childhood contagions in classrooms during 21 school years' experience[5]. Six foot watts of irradiation per pupil exceeded threshold sanitary ventilation in classrooms during the winter[4]. Scientific definitions, principles, formulations, and derivations of factors governing the formulations of the radiant disinfection of air are being summarized in a paper being prepared by the author.

Table 1—Equivalent Recirculation

Beam Elevation	L	L_o	L/L_o	L_o/A	L/A	4
High	1.2	3.8	0.31	3.1	0.96	2
Low	8.2	12.8	0.64	1.0	0.62	1.8
Low with visor	3.7	10.2	0.36	2.6	0.96	9

L = negative natural logarithm of fraction of survivors.
L_o = 500 times product of mean ray length in feet, lethal flux in watts, and time in minutes divided by room volume in cubic feet.
A = equivalent recirculation through irradiation, L_o, in exchanges or overturns per minute.

Acknowledgment

The figures, data and most of the text on Lethal Exposure, Lethal Gradient, and Average Lethal Exposure are reprinted by permission of the Journal of the Franklin Institute. The author is grateful for this courtesy.

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Discussion

B. H. JENNINGS, Evanston, Ill. (WRITTEN): Professor Wells is to be congratulated on his fine paper which analyzes the probabilities of air-borne infection taking place and discusses the problems associated with setting up standards for measuring sanitary ventilation. Much work needs to be done in this connection and it is important to bring it before the attention of ventilation and sanitary engineers.

I would like to add a few words concerning sanitary ventilation by chemical disinfection which is less well understood than radiant disinfection. Much of the earlier work with chemical disinfection was concerned with establishing chemical atmospheres in a treated space of such quality that immediate killing of all bacteria occurred. This desirable objective can be accomplished with triethylene glycol vapor of adequate concentration, under conditions where relative humidity is not excessively high nor excessively low. This requires concentrations at 75 F of approximately 0.004 milligram of triethylene glycol per liter of air and the fog limit for the triethylene glycol vapor is approached. A triethylene glycol fog is not deleteri-

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ous, but it is objectionable from an appearance viewpoint and from the possibility of condensation on cold surfaces.

Recent work in this field has been conducted in connection with investigating the air-sterilization effectiveness of glycol vapor in relatively low concentrations, namely in the range 0.001 to 0.002 milligram per liter of air. Controlled bacterial tests show that killing of all bacteria is not instantaneous but an extremely great reduction in bacterial colony count occurs and, in time, test plates show no evidence of any bacterial life remaining in a treated room. Some of the elimination of bacterial activity can be attributed to the natural dying out rate, but the greater portion of it appears definitely to take place because of the triethylene-glycol-vapor action.

Standards for such air sterilization should also be set up, and more papers of the type of this fine paper by Professor Wells should be presented before the Society.

AUTHOR'S CLOSURE: The generous remarks of Professor Jennings' are especially appreciated because he has devoted so much time in recent years to the study of sanitary ventilation by chemical disinfection. His discussion emphasizes the distinction between *sterilizing* air in a laboratory experiment and the practice of air disinfection in sanitary ventilation; sterilization is not necessary to prevent the dynamic spread of airborne contagion.

I heartily agree with his statement that much work needs to be done by sanitary and ventilation engineers.

New Chapter at Shreveport

The organization meeting of the Shreveport Chapter was held May 6 in the Council Chamber of City Hall with A. H. Otto presiding as temporary chairman. Officers were nominated and the following were elected: *President*—W. E. FitzGerald; *Vice President*—E. J. Kearby; *Treasurer*—B. E. Segall, Jr., *Secretary*—O. J. Dykes, Jr.; *Board of Governors*—A. H. Otto, R. M. Hood, and M. A. Hudson. Immediately following the election the new officers took charge and President FitzGerald gave a resumé of the circumstances surrounding the formation of the Shreveport Chapter and outlined the plans for future meetings. Standing committees were then appointed as follows: Membership Committee composed of E. J. Kearby, *Chairman*, R. F. Zimmerman, B. E. Segall, Sr., P. H. Kolb, and P. O. Rottman. Meeting Committee composed of A. H. Otto, *Chairman*, M. A. Hudson, O. J. Dykes, Jr., J. B. Struwe and M. M. Heller. Finance Committee composed of B. E. Segall, Jr., *Chairman*, C. E. Richardson, S. W. Beaty, T. E. Spangenberg, and A. L. Zwally. Legislative Committee composed of R. M. Hood, *Chairman*, M. W. Finuf, Sr., and W. H. Cheatwood. It was decided that the Board of Governors would submit by-laws for the approval of the chapter at a business meeting in the near future.

The Charter meeting of Shreveport Chapter was held at Monsours with 63 present on May 19. President FitzGerald welcomed the group and A. H. Otto, chairman of the meetings committee, conducted the program. R. F. Taylor, Houston, Tex., member of the Society's Council, spoke of the Aims and Ambitions of ASHVE and presented the charter on behalf of the Council. A. V. Hutchinson, New York, N. Y., secretary of the Society, spoke briefly on chapter activities and operation. C. Rollins Gardner, Dallas, Tex., president of the North Texas Chapter, and D. M. Mills, Houston, Tex., president of the South Texas Chapter, told of the value of chapter membership.

The main speaker of the evening was Carl F. Boester, Lafayette, Ind., director of Housing Research, Purdue University, and Member of Council, whose subject was Reverse Cycle Refrigeration Combined with Radiant Heating as Applied to Small Homes. Following Mr. Boester's talk there was an interesting discussion.

Heat Conduction With Engineering and Geological Application

By L. R. Ingersoll, O. J. Zobel and A. C. Ingersoll

This book will provide convenient references for engineers covering the theory and application of heat conduction. Typical chapters on conduction of heat are: Steady State—One Dimension; Steady State—More than One Dimension; and Periodic Flow—One Dimension.

Beginning with an introduction of symbols, definitions and fundamental heat conduction equations, the book treats heat flow in steady state in one and more dimensions. This is followed by a chapter on Periodic Heat Flow, and a chapter on the Fourier Series.

Linear Heat Flow is discussed, and typical applications are made to conduction in soil, concrete walls, metal and wood blocks, etc. Applications to practical cases involve heating of fireproof walls, freezing and thawing of soil, removal of shrink-fitted metal shapes, estimating of earth cooling rates, and age of the earth.

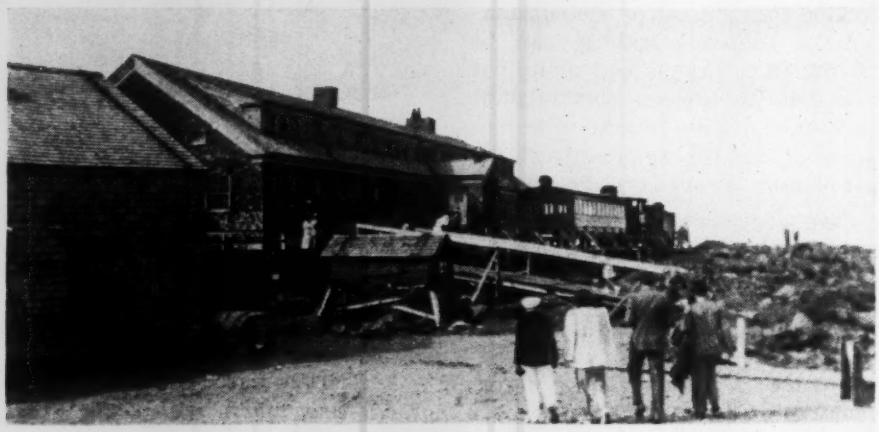
The instantaneous and continuous heat source theory, as used by Kelvin and others, is developed in relation to heating and cooling of solids, and in finding earth temperatures resulting from addition or extraction of heat from the earth.

Examples are given to show methods of calculating temperatures in buried pipes such as used in heat pump installations. One chapter is devoted to problems involving freezing and thawing of ice.

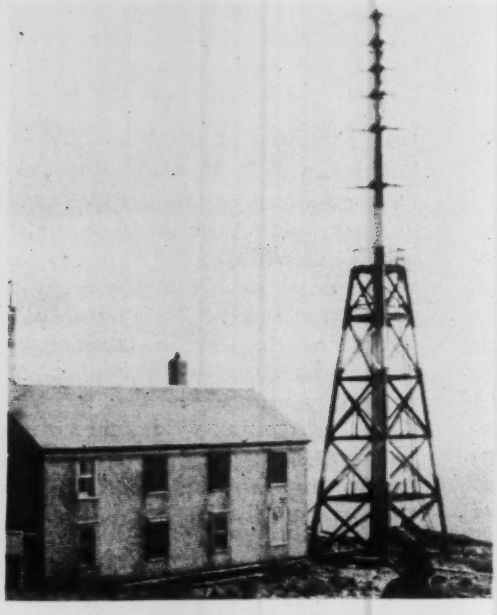
Auxiliary methods are given for solving heat conduction problems by graphical, electrical and computational processes. The final chapter covers methods of determining thermal conductivity constants.

The book is published by the McGraw-Hill Book Co., New York, and is sold at $4.00 a copy.

Mount Washington Trip



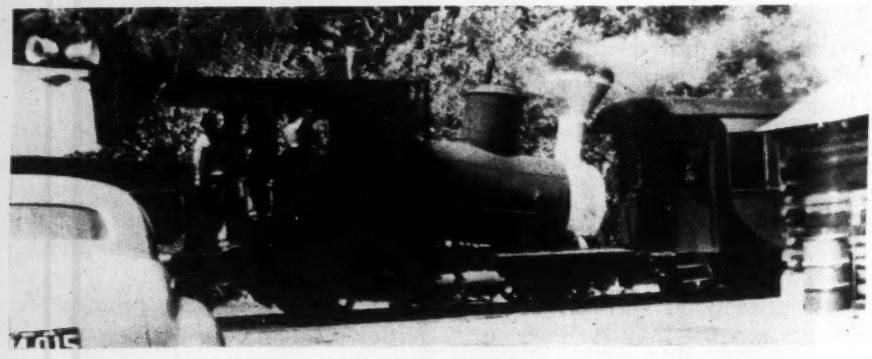
On top of the World



Weather Station at the summit

Mr. and Mrs. A. A. Bearman, New York, N. Y. and R. D. Madison, Buffalo, N. Y.

Ready for the Mt. Washington Trip



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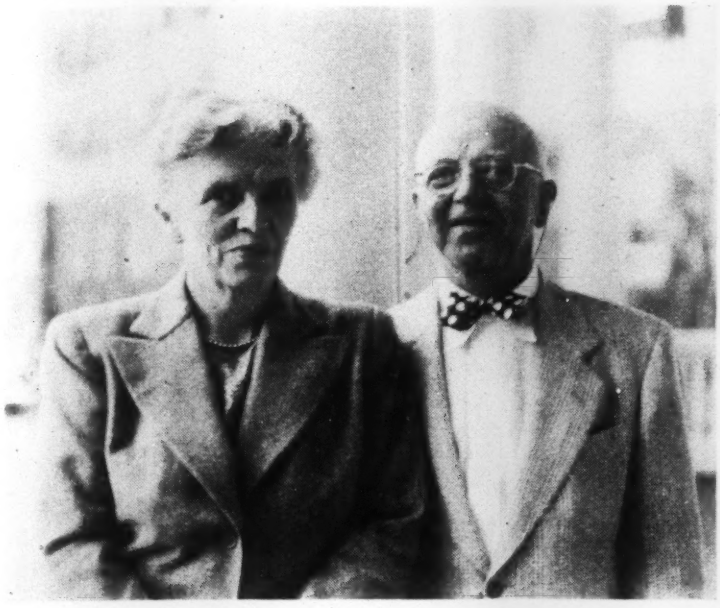
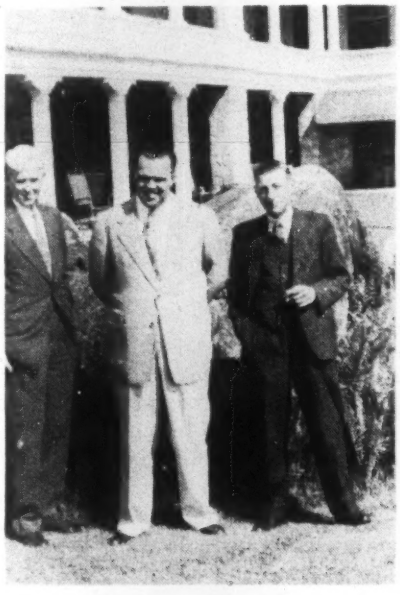
MEMBERS at BRETTON WOODS

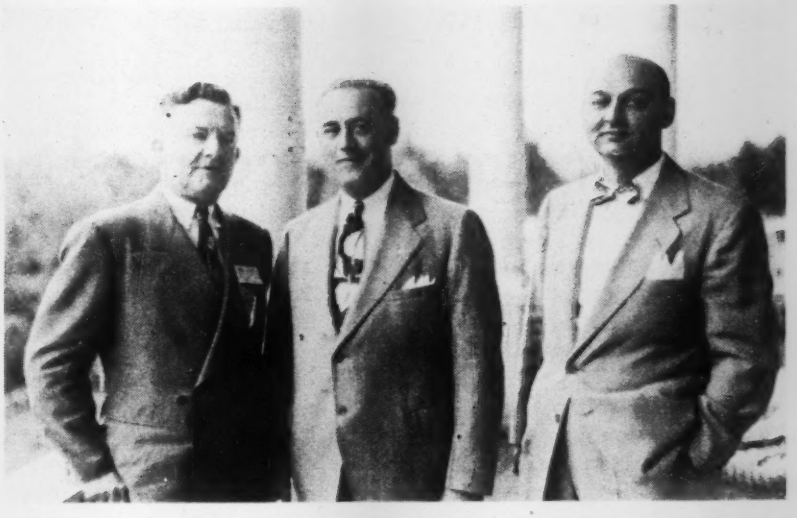


Mr. and Mrs. H. Berkley Hedges, Wyncote, Pa.

1st Vice Pres. A. E. Stacey, Jr. Syracuse, N. Y.



Pres. G. L. Tuve, L. N. Hunter, chairman, Committee on Research, and Dr. Thomas Bedford, London, England



(l. to r.) C. Rollins Gardner, Dallas, Tex., W. R. Moore, R. L. Byers, Cleveland, Ohio

(l. to r.) Mrs. Avery, Messrs. Leopold, Williams, Haines, Mrs. Haines, Messrs. Osborn and Shipp with the catch

Chicago skyline looking north along Michigan Ave. Kaufmann & Fabry Co.

Chicago Welcomes Society Meeting

THE program is well under way for the Society's 55th Annual Meeting, which will be held in Chicago during the fourth week of January 1949.

The Illinois Chapter will be host for the occasion, and C. M. Burnam, Jr., its president, announces the following Committee on Arrangements: W. A. Kuechenberg, *general chairman;* J. H. Milliken, *vice chairman;* M. J. Bamond and H. G. Chapin, *banquet;* J. S. Kearney, *entertainment;* G. W. Bornquist, *exposition;* P. J. Marschall, *finance;* O. J. Prentice, *publicity;* M. W. Bishop, *reception;* and G. V. Zintel, *sessions.*

Meeting headquarters will be at the Stevens Hotel, and the other hotels cooperating in housing those who plan to attend the Society's Annual Meeting and the 9th International Heating and Ventilating Exposition are: Allerton, Ambassador East, Atlantic, Bismarck, Blackstone, Brevoort, Chicagoan, Congress, Continental, Hamilton, Harrison, Knickerbocker, LaSalle, Maryland, Midland, Morrison, Palmer House, Parkway, Plaza, St. Clair, Sherman, Sherry, Shoreland, Stock Yards Inn, and the Wacker.

The Program Committee is planning five technical sessions, beginning on Monday, January 24, and it is expected that among the subjects to be discussed will be fuels, industrial ventilation, physiological reactions to environment, and research reports on subjects now being investigated at the Society's Laboratory and at cooperating Universities.

The local Committee on Arrangements of the Illinois Chapter is now planning the social program which includes a get-together luncheon, a social hour for members and ladies, and the banquet. Special events for ladies will be announced later.

W. A. Kuechenberg
General Chairman
Committee on Arrangements

During the month of August, it is planned to send to all members special hotel reservation forms, and it is hoped that requests will be filed promptly with the hotel of the member's choice. Adequate accommodations have been reserved at the various hotels to meet the requirements of all who will attend the meeting and exposition.

The 9th International Heating and Ventilating Exposition will be held at the International Amphitheatre, and over 300 exhibitors have reserved all available space.

From all indications this will be the Society's largest meeting and the most extensive exposition of heating and ventilating equipment.

The Illinois Chapter members look forward to welcoming members of the Society from all parts of the world during the week of January 24-28, 1949.

Summary of Local Chapter Meetings*

Atlanta—June 11, 1948. An entertaining program was presented at the last meeting of the season, first a "*technical paper*" presented by *Ivan Garovitch*, was a burlesque by a professional comedian. Various interruptions prevented the delivery of the "*President's Message*" by Pres. L. L. Barnes. After a "*Report From Rio*", by S. W. Boyd, a fashion show with the *new look* was put on by the male members of Atlanta Chapter, who displayed the latest in *women's* fashions. The models (?) were Messrs. Sheehan, Kagey, Fenn, Crowley, and Hightower. Attendance 69. Attendance ratio 0.60.

•

Connecticut—June 25, 1948. A nontechnical meeting was held at the Avon Country Club, Avon, Conn., following dinner and a golf game. A short business meeting was held at which the members unanimously approved an amendment to the chapter by-laws which increases the annual dues of all members and associate members. An entertainment program concluded the day's events. Attendance 62. Attendance ratio 0.27.

•

Indiana—May 28, 1948. The retiring President, I. W. Cotton, expressed his appreciation for the cooperation of all members in the administration of chapter activities for the past year, and turned the meeting over to C. J. Carlson, chairman of the nominating committee, who announced the election of officers as follows: *President*—P. R. Jordan; *Vice President*—W. R. Fenstermaker; *Secretary*—C. F. A. Locke; *Treasurer*—F. A. Stickle; *Board of Governors*—W. E. Goohs, C. H. Hagedon, and I. W. Cotton. The appointment of Mr. Cotton as chapter delegate to the Semi-Annual Meeting, with G. B. Supple as the alternate, was announced. P. R. Jordan reported that $162.50 had been received from chapter members for the Research Mortgage Retirement Fund, and Treas. F. S. Boone reported a bank balance of $656.57. The program was then turned over to J. H. Niesse who introduced F. M. Johnson, Surface Combustion Corp. Toledo, Ohio, who talked on Dehumidifying Equipment and i's Relationship to Air Conditioning.

•

Memphis—June 21, 1948. Following the introduction of the standing committees by Pres. E. E. Scott, past president's pins were presented to T. J. O'Brien, R. H. Hoshall, and N. C. Ledbetter. A film entitled, *Water, Water, Everywhere*, was shown through the courtesy of the American Cyanamid Co. This sound film, dealing with the treatment of water by ionization, was in technicolor. On the basis of the reports from the cards mailed to the membership regarding the change in meeting nights, it was agreed to continue on the third Monday night in the month. Attendance 23. Attendance ratio 0.34.

•

Montreal—June 9, 1948. The committee for the golf meet, held at the Whitlock Golf and Country Club, consisted of Jack Wright, F. A. Sheppard, and B. J. Horsburgh. Leo Garneau presided at the meeting, and then turned the presentation of awards over to Mr. Horsburgh. Attendance 55.

Montreal—May 18, 1948. At a luncheon meeting George Ganetakos made a brief informal talk and A. McPherson then gave a running commentary on some moving pictures taken by Mr. Ganetakos at various golf meets during the past two years. Attendance 35.

North Texas—June 21, 1948. J. P. Ashcraft, program chairman, introduced the speaker of the evening, H. L. DeVines, mechanical engineer, Houston, Tex., and member of the South Texas Chapter, who gave an enlightening and educational talk on the Atomic Theory as Applied to Air Conditioning. He pointed out many new sources in connection with the generation of atomic energy for air conditioning purposes. A lively discussion followed, which lasted until adjournment. Attendance 92. Attendance ratio 0.50.

•

Rocky Mountain—May 5, 1948. P. W. Young introduced the guest speaker, G. A. Voorhees, of the *National Warm Air Heating and Air Conditioning Association*, who spoke on recent work in the Research Residence at the University of Illinois. Mr. Voorhees said that experiments on ceiling panel heating alternated at two-week intervals with warm air heating, showed a 17 percent greater fuel consumption for panel heating, due perhaps to inadequate insulation in the ceiling, and the best heating results were obtained with a combination of panel and warm air heating. According to Mr. Voorhees, factors often neglected or given insufficient attention in heating design are: (1) accurate determination of heating requirement; (2) proper location and sizing of air diffusers and returns, and (3) adequate control equipment. An active discussion followed the talk. Attendance 39. Attendance ratio 0.29.

•

Southwest Texas—July 7, 1948. Aims and Activities of the Society was the title of the talk given by Reg. F. Tayor, Houston, Tex., a member of the Society's Council. The chairman of the committee, appointed to compile a constitution and set of by-laws, presented the committee's suggested work for approval, and after considerable dis-

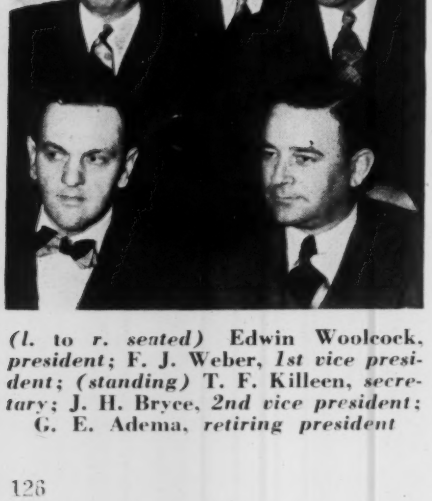
* Note: The attendance ratios shown represent the membership attendance divided by the chapter membership. These ratios will be useful as a partial indication of interest shown by local chapter members in various types of subjects programmed by the various chapters and may be useful in deciding on subjects for chapter meetings.

cussion, it was voted to accept the by-laws. Officers elected to serve until December 31, 1948 are: *President*—G. R. Rhine; *Vice President*—L. S. Pawkett; *Secretary-Treasurer*—I. W. Wilkie. As an added feature, H. L. DeVines presented his *demonstration model* and discussion of the Atomic Theory as Applied to Air Conditioning. Attendance 39. Attendance ratio 0.86.

•

Washington—May 12, 1948. The meeting opened with a humorous talk, along the pattern of the late Robert Benchley, by F. J. Weiss, in which he gave an imaginary audit of the Chapter's books. This *exposé* provoked many laughs and was a pleasant and diverting surprise. J. G. Muirheid, secretary, then referred to an address to be delivered before the *District of Columbia Society of Engineers* by Dr. D. B. Steinman, authority on engineering registration laws. After introducing the new chapter officers, A. S. Gates, Jr., vice president, mentioned that the number of Associate Members of the Society was out of proportion to the number of Members on the rolls, and he urged all eligible Associate Members to apply for advancement. Two sound films were then shown, one of an atom bomb documentary short subject, and the other a color cartoon depicting life in *Bugville* and the community's demise on the entrance of ultra-violet rays. The latter film served to illustrate the address presented by H. C. McInteer, Eastern Ultra-violet Co., on the Effect of Ultra-Violet Radiation on Air Borne Bacteria. Mr. McInteer described the types of ultra-violet rays and the advantages of each. He listed the hazards of ultra-violet installations and suggested several safety measures. Several typical installations were described. Mr. McInteer stated that the purpose of his talk was to focus attention on the potentialities of the ultra-violet ray. Attendance 43. Attendance ratio 0.11.

Western New York Chapter Officers



(l. to r. seated)* Edwin Woolcock, *president*; F. J. Weber, *1st vice president*; *(standing)* T. F. Killeen, *secretary*; J. H. Bryce, *2nd vice president*; G. E. Adema, *retiring president

Student Branches

Purdue Student Branch—July 7, 1948. Robert Bonwell, graduate of Purdue University, conducted an interesting discussion on the Practical Aspects of Warm Air Panel Heating. Among the facts stressed in the discussion was the restriction of warm air panel heating to new homes because of the high construction cost of drop ceilings in old homes. He stated that furnace fuels are restricted to gas, oil, or electricity, since such a system requires an instantaneous and variable heat supply. In his discussion, Mr. Bonwell included the showing of typical fittings used in a warm air panel system. A diagram of a house was drawn to illustrate the characteristics of a warm air distribution system and he pointed out that effective design requires that the warm air reach the outside walls as quickly as possible. An informative question and answer period followed. J. H. Miller reported on the work being carried on by his membership committee in the organization of a membership data card file, and B. E. Petry, chairman of the program committee, conducted a short discussion on plans for a picnic to be held during the summer semester. After an expression of gratitude to Mr. Bonwell and the introduction of guests, R. G. James, chairman, announced that the first fall meeting would be held on October 13. Attendance 28.

A. J. OFFNER RETIRES

Alfred J. Offner, consulting engineer and former president and treasurer of the Society, announced his retirement from active practice on September 1, 1948.

He opened his own consulting offices in 1930, and has designed the mechanical equipment for numerous government, commercial, and private buildings in the United States, Europe, South America and Asia. Mr. Offner served as president of the Society's New York Chapter, also as president of the *New York Association of Consulting Engineers*, and is a member of the board of governors of the New York Building Congress. He is listed in both *Who's Who in Engineering* and in *Who's Who in America*. Mr. Offner lives at 160-15 11th Avenue, Beechhurst, L. I., N. Y.

MILLER NEW DEAN AT MICHIGAN STATE

Lorin G. Miller has been appointed Dean of the School of Engineering at Michigan State College, East Lansing, Mich. Dean Miller, who assumed his new post on July 1, has been head of the department of Mechanical Engineering since 1935.

Dean Miller joined the ASHVE in 1933, and served on the Council, 1942-44. In 1946 he was elected to serve a three-year term as a member of the Committee on Research. At present he is serving on the Research Technical Advisory Committees on Air Cleaning, Air Distribution, and Physiological Research. He is an active member of the Western Michigan Chapter, where he has served as vice president and president in 1935 and 1936 respectively.

He also served as president of the Michigan Chapter of the American Society for Engineering Education and at present is a member of the Short Course Committee of *IBR*.

Dean Miller received his B.S. in 1910 and B.S. in Electrical Engineering in 1911 from Highland Park College, Des Moines, Ia., and took advanced graduate work at the Massachusetts Institute of Technology. Before coming to Michigan State College in 1929, as professor of mechanical engineering, he had been employed with the Western Electric Company and as a pro-

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fessor at the University of Wisconsin.

He succeeds Dean Henry B. Dirks, retired, and his appointment is considered significant in view of the College's current expansion and modernization of engineering facilities.

Candidates for Membership

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When the replies are received from references, the candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 69 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn, the Council, urge members to assume their share of responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by September 25, 1948, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

ALLEN, EUGENE P., Sales, Crane Co. PROPOSERS: R. M. Towne, R. H. Liniger. SECONDERS: D. O. Mead, C. I. Vinsonhaler.

BARBOUR, RONALD G., Chief Elec. & Mech. Engr., T. Pringle & Son Ltd. PROPOSERS: A. E. Horsburgh, F. G. Phipps. SECONDERS: Robert Clapperton, H. G. S. Murray.

BRAINERD, J. L., Partner, A. Wilcox Co. PROPOSERS: C. A. Pangborn, R. H. Liniger. SECONDERS: D. O. Mead, R. O. Wesley.

BRANCHE, WILLIAM H., Project Engr., Bryant Heater Co. PROPOSERS: W. R. Teller, K. T. Davis. SECONDERS: H. W. Heisterkamp, C. G. Allen.

BROWN, ROSS E., Application Engr., Minneapolis-Honeywell Regulator Co. PROPOSERS: W. R. Lee, F. M. Thomas. SECONDERS: A. D. Holmes, H. W. Meinholtz.

CORBETT, CHARLES L., JR., Designer, C. F. Braun & Co. PROPOSERS: R. S. Farr, Maron Kennedy. SECONDERS: Leo Hungerford, L. J. Helms.

DANCY, F. M., Application Engr., York Products Div., Modern Appliances Inc. PROPOSERS: D. S. Sterner, R. L. Beach. SECONDERS: E. C. Harper, S. N. Roberts.

DAVIS, H. F., Student, Purdue University. PROPOSERS: F. B. Morse, H. G. Pfennig. SECONDERS: J. H. Miller, R. G. James.

DAWSON, DONALD F., Mech. Engr., C. F. Braun & Co. PROPOSERS: R. S. Farr, Maron Kennedy. SECONDERS: Leo Hungerford, L. J. Helms.

DOVER, G. KENT, Sales Engr., Chase Brass & Copper Co. PROPOSERS: J. W. Scharres, A. N. Nelson. SECONDERS: C. C. Graves, F. W. Thompson.

DRYER, ELDON O., Product Engr., Mastic Asphalt Corp. PROPOSERS: M. S. Wunderlich, L. H. Mattes*. SECONDERS: H. H. Reinecke*, C. P. Larson.

ECHOLS, M. PATTON, JR., Sales Engr., York Corp. PROPOSERS: M. M. Crout, R. L. Beach. SECONDERS: E. C. Harper, I. B. Kagey.

EFT, N. W., Student, University of Illinois. PROPOSERS: R. J. Martin*, Francis Seyfarth*. SECONDERS: H. D. Bareither, D. G. Ryan*.

GENCARELLI, GEORGE C., Engr., Armo Cooling & Ventilating Co. PROPOSERS: P. J. Barbieri, Peter Franck. SECONDERS: Joshua Kheel, Murray Gordon*.

GONZALEZ, JOSE I., Instructor, Purdue University. PROPOSERS: Y. S. Touloukian, F. B. Morse. SECONDERS: W. T. Miller, C. F. Warner.

HALE, ARTHUR B., Prof. Engr. PROPOSERS: Roger Macnamara, G. P. Patterson. SECONDERS: R. B. Dowdy, Bob Molnari.

HARDY, JAMES W., Owner, James W. Hardy, Htg. Contr. PROPOSERS: M. J. Bamond, H. F. Stamps. SECONDERS: G. W. Bornquist, C. M. Burnam, Jr.

HEPNER, RAY, Service Mgr., Slawson Equipment Co. PROPOSERS: J. J. LaSalvia, S. F. Frensdorf. SECONDERS: L. E. Slawson, L. C. Burkes.

HISCOCK, WILLIAM J., Dist. Sales Engr., Vapor Car Heating Co. PROPOSERS: Milner Noble, L. H. Fritzberg. SECONDERS: L. A. Childs, R. P. Allsop.

HOFFMAN, LOUIS B., Sales Engr., Hoffman & Hoffman Co. PROPOSERS: E. S. deWitt, H. B. Hoffman. SECONDERS: E. G. Embree, R. M. Warren, Jr.

IMMING, CORNELL A., Vice Pres., O. A. Wendt Co. PROPOSERS: M. J. Bamond, C. M. Burnam, Jr. SECONDERS: F. W. Thompson, W. A. Kuechenberg.

JOHNSON, LLOYD R., Sales Mgr., Guy E. Murphy Co. PROPOSERS: E. F. Hyde, W. B. Dixon. SECONDERS: B. H. Bigham, R. G. Hurlburt.

JOHNSON, ROY W., Partner, Johnson & Lenz (*Advancement*). PROPOSERS: R. H. Hoshall, N. C. Ledbetter. SECONDERS: J. D. Flinn, C. S. Fischer.

KESSELER, CHARLES J., Bldg. Supt., Philtower Bldg. PROPOSERS: W. R. Lee, Edwin Jones. SECONDERS: J. E. Buckley*, H. W. Looney*.

KHEEL, JOSHUA, Pres., Colby Air Conditioning Corp. PROPOSERS: Peter Franck, Ralph Torop. SECONDERS: P. J. Barbieri, H. M. Weitzner*.

KIMBRELL, JACK T., Asst. Prof. of Mech. Engrg., University of Missouri. PROPOSERS: R. L. Scorah*, M. M. Bolstad*. SECONDERS: W. H. Miller*, Paul Ogden*.

KIRSCH, W. R., Partner, C. S. Guenzel Co. PROPOSERS: G. E. Merwin, P. J. Pospisil. SECONDERS: G. W. Colburn, F. W. McCarthy.

KRIEG, TOM E., Federal Supply Co. PROPOSERS: E. F. Dawson, G. T. Donceel. SECONDERS: E. T. P. Ellingson, J. H. Spaan.

KROCK, THOMAS P., Dir. of Govt. Services, Design Service Co. PROPOSERS: L. E. Seeley, S. K. Smith. SECONDERS: E. G. Carrier, R. L. Blanding.

KUPETZ, FRANCIS, Co-Owner, Kupetz Bros. Htg. & Plbg. Co. PROPOSERS: L. F. Tierney, F. C. McIntosh. SECONDERS: W. F. Stanger, A. R. Borton.

LANG, R. E., Plant Engr., Western Electric Co., Inc. PROPOSERS: Joseph Davis, J. H. Bryce. SECONDERS: M. C. Beman, E. P. Brown.

LAVERTY, FRANK J., Designing Engr., U. S. Bureau of Reclamation. PROPOSERS: J. E. McNevin, F. L. Adams. SECONDERS: G. D. Maves, E. J. McEahern.

LEFRANCOIS, J. G., Partner-Owner, Lefrancois & Laflamme. PROPOSERS: T. H. Worthington, R. A. Standring. SECONDERS: Leo Garneau, B. J. Horsburgh.

LENZ, ALFRED W., Partner, Johnson & Lenz (*Advancement*). PROPOSERS: N. C. Ledbetter, R. H. Hoshall. SECONDERS: J. D. Flinn, C. S. Fischer.

MACKENZIE, K. W., Product Mgr., Raytheon Mfg. Co. PROPOSERS: A. J. Hess, F. H. Brigham. SECONDERS: C. R. Swaney, N. J. H. Shaw.

* Non-Member

MAGUIRE, HUGH E., Designer, C. F. Braun & Co. PROPOSERS: R. S. Farr, Maron Kennedy. SECONDERS: Leo Hungerford, L. J. Helms.

MAYES, RICHARD A., Sales Engr., Westinghouse Electric Corp., Sturtevant Div. PROPOSERS: S. A. Ellsberry, Jr., M. J. Murray. SECONDERS: J. C. Chase, Oslin Nation.

McDORMAN, WILLIAM A., Lustron Corp. PROPOSERS: A. I. Brown, S. M. Marco*. SECONDERS: S. R. Beitler*, C. A. Norman*.

McMANUS, P. L., Sales Engr., Worthington Pump & Machinery Corp. PROPOSERS: E. A. Ponder, J. D. Kroeker. SECONDERS: R. C. Chewning, K. H. Hanson.

MILES, VERDIE W., Htg. & Indus. Engr., Oklahoma Natural Gas Co. PROPOSERS: W. R. Lee, F. M. Thomas. SECONDERS: A. D. Holmes, R. W. Winget.

MOORE, CARL W., Pres., J. L. Heath Co. PROPOSERS: A. D. Holmes, Edwin Jones. SECONDERS: H. W. Meinholtz, W. R. Lee.

NASH, RICHARD C., Branch Mgr., American Radiator & Standard Sanitary Corp. PROPOSERS: W. E. FitzGerald, R. F. FitzGerald. SECONDERS: A. H. Otto, B. Segall, Jr.

PARR, WILLIAM G., Partner, Parr & Aderhold. PROPOSERS: J. R. Patten, H. S. Shafer. SECONDERS: J. H. Carnahan, W. M. Carroll.

PARROS, GEORGE J., Design Engr., Theodore F. Rockwell, Cons. Engr. PROPOSERS: G. W. Cost, T. F. Rockwell. SECONDERS: C. M. Humphreys, F. C. McIntosh.

PINGREY, DONALD W., Sales Engr., Puget Sound Refrigeration. PROPOSERS: R. W. Crain, Sr.*, D. O. Mead. SECONDERS: C. I. Vinsonhaler, W. W. Philbrick*.

PLEUTHNER, RICHARD L., Asst. Prof of Engrg., University of Buffalo (*Advancement*). PROPOSERS: R. K. Smith, F. H. Thomas*. SECONDERS: C. M. Fogel*, P. E. Mohn*.

PORWOLL, LEONARD J., Student, Dunwoody Industrial Institute. PROPOSERS: F. H. Schneeberg, H. K. Heikkinen. SECONDERS: William Sturm, John Rudberg.

PURIFOY, BOYD F., Owner, Frank McPherson. PROPOSERS: W. R. Lee, Edwin Jones. SECONDERS: A. D. Holmes, F. M. Thomas.

QUIROS, MARCOS MENENDEZ, Partner, Menendez y Trujillo. PROPOSERS: R. B. Caughman, K. L. Crapeau*. SECONDERS: M. A. Cadenas, Jr., A. G. Loeffel*.

RHEAUET, JOSEPH A., Pres., Homestead Heating & Engineering. PROPOSERS: Winfield Roeder, G. F. Murray. SECONDERS: J. H. Phelan, E. C. Marsden.

RIBAR, LAUDY, Student, Dunwoody Institute. PROPOSERS: F. H. Schneeberg, H. K. Heikkinen. SECONDERS: William Sturm, John Rudberg.

ROGERS, LYMAN F., Mgr., The Trane Co. PROPOSERS: Winfield Roeder, J. R. Smak. SECONDERS: N. R. Miller, D. M. Hummel.

ROMA, CHARLES, JR., Htg. & Vtg. Engr., Daniel Const. Co. & F. H. McGraw & Co. Associates. PROPOSERS: C. S. Fischer, T. O. S. Humphrey, Jr. SECONDERS: E. E. Scott, A. T. Bevil.

SAKOLS, D. JAMES, Mech. Engr., Healy Plumbing & Heating Co. PROPOSERS: William McNamara, J. R. Peterson. SECONDERS: William Sturm, G. M. Kendrick.

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ALFRED E. KNIBB DIES AFTER LONG ILLNESS

After a long illness, Alfred E Knibb, Detroit, Mich., president of the Michigan Chapter during 1947-48, died on July 17.

Mr. Knibb was born in London, England in 1891, and came to Canada in 1911, settling in Regina, Sask. At the outbreak of World War I, in 1914, he returned to England and enlisted in the British Navy. He returned to Canada in 1919; and later became the superintendent of various heating contracting firms in Pittsburgh, Pa. He was affiliated with the L. L. McConachie Co., Detroit, as a heating engineer, until his death.

Mr. Knibb has been a member of the ASHVE since 1930 and will be missed at Society meetings which he attended regularly. He is survived by his wife, Rose; a brother, Fred; and a sister in England.

E. M. FENNER DIES SUDDENLY

Everett M. Fenner, chief engineer of the Scientific Engineering Co., Centredale, R. I., passed away suddenly on June 12, 1948.

Mr. Fenner was a native of Cranston, R. I., and joined the Society in 1928. From 1931 to 1939 he was associated with the Staples Coal Co., Fall River, Mass. For the next six years he was a designer and estimator with the War Department, U. S. Army Engineers, in Providence, R. I. From 1946 until his death Mr. Fenner was the owner and chief engineer of the Scientific Engineering Co. Mrs. Fenner and three sons survive.

DEATH OF J. W. CLOSE ANNOUNCED

James W. Close, native of Chicago, Ill., died unexpectedly on July 1, in his 56th year and his passing was a shock to his friends of the Illinois Chapter. He was born in 1892 and attended the Murray F. Tuley High School. He then entered the sheet metal field which became his life work. At the time of his death he was general secretary-treasurer of the *Sheet Metal Workers International Association* and editor of the *Sheet Metal Workers Journal*. Mr. Close had held ASHVE membership since 1944.

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Wisconsin: Organized, 1922. Headquarters, Milwaukee, Wis. Meets, Third Monday. President, W. A. Ouweneel, 514 E. Ogden Ave., Milwaukee 2. Secretary, H. F. Brinen, 2226 Kinzie Ave., Racine.

Student Branches

North Carolina State College: Organized 1948. Headquarters, Raleigh, N. C. President, J. G. Marshall, North Carolina State College. Secretary, Basil Greene, Apt. D-2, Grosvenor Garden Apts., Raleigh.

Purdue University: Organized 1948, Headquarters, W. Lafayette, Ind. Chairman, R. G. James, 411 E. 37th St., Indianapolis. Secretary, D. M. Long, FPHA Apt. 423-2, W. Lafayette.

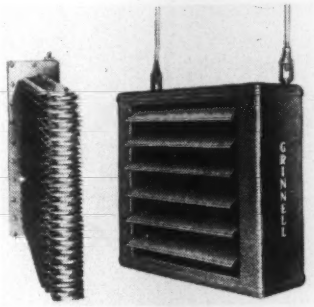
Texas A. & M. College: Organized, 1946. Headquarters, College Station, Tex. Meets, Third Thursday. President, S. E. Ammons, 212 13th Ave., No., Texas City. Secretary, C. P. Howard, Box 1706, College Station.

UNIVERSITY OF MICHIGAN LIBRARIES

EQUIPMENT DEVELOPMENTS

For your convenience in obtaining more information about any of this equipment, see coupon on this page. Add the new products and companies listed here to your Directory Section which you received in your January 1948 Heating, Piping & Air Conditioning and thus keep your records of sources of supply up to date throughout the year. Single asterisk indicates equipment not listed in Directory Section; double asterisk equipment and manufacturer not listed.

Develops Unit Heater for Dust, Lint Laden Atmospheres

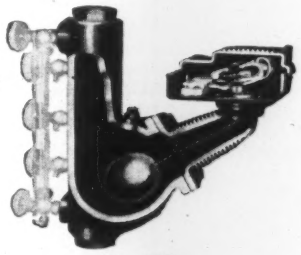


No. 3853 — Grinnell Co., Inc., 260 W. Exchange, Providence 1, R. I., has deoped a "Thermolier" unit heater for use in dust and lint laden atmospheres, such as occur in many departments of textile mills, etc.

Designed to maintain its heat transfer capacity under adverse operating conditions and with a minimum of cleaning maintenance, the heater incorporates heat transfer surfaces of a new design having smooth contours so that a jet of air from a compressed air hose or from a portable electric hand blower may be used to clean the device. According to the manufacturer, a high volume of air delivery provides a partial self cleaning action which will maintain the heater's capacity for long operating periods.

It is offered in one size with a capacity of 113,700 Btu per hour, using steam at 2 psi and entering air at 60 F. The capacity is said to be 143,400 Btu per hour when using steam at 25 psi, and any steam pressure up to 125 psi can be used.

Protects High Pressure Boilers



No. 157

No. 3854 — The No. 157 safety control, designed for use with high pressure boilers by McDonnell & Miller, Inc., Wrigley Bldg., Chicago, includes a self contained water column, a low water cutoff, a pump control, a low water alarm, or any combination of these functions.

Offered for a maximum steam pressure of 150 psi, the device is actually the company's No. 150 control in a new water column form. The new arrangement, says the company, practically eliminates all equalizing piping and fittings so that installation is quick, simple, and trim. Reproduction of the boiler water level is said to be ideal and direct blowdown can be provided.

Another important feature is said to be the positioning of all tappings for the water glass and try cocks in the end of the body so that the unit may be located on either side of the boiler.

Fabricates Pipe Fitting Covers of Cellular Glass

No. 3855—The manufacture of preformed, factory-made, pipe fitting covers of "Foamglas" for both hot and cold fittings, has been announced by Pittsburgh Corning Corp., 632 Duquesne Way, Pittsburgh.

Designed for use with the company's recently introduced pipe insulation, the new cellular glass pipe fitting covers are said to be particularly suitable for the petroleum, chemical processing, and allied fields where exact temperature control is required—whether heat is to be retained or excluded.

The covers are being manufactured in all sizes for ells, tees, unions, valves, elbows, and flanges.

The insulating material, says the company, is not affected by humidity, is waterproof, vaporproof, fire retardant, and highly resistant to fumes, acids, and many other elements. The covers are designed for temperature ranges from —200 to 800 F.

Refractory Concrete Withstands High Temperatures

No. 3856—A high strength, chrome base refractory concrete, known as "Kromcast," which is designed to withstand temperatures as high as 3100 F, has been developed by Babcock & Wilcox Co., 85 Liberty St., New York 6, N. Y. The product is said to be of major importance for industrial furnaces because it is an easily installed concrete combining the refractory and slag resisting properties of chrome base materials with the ability to support loads at high temperatures.

According to the company, it can be poured into place as easily as ordinary concrete or applied by plastering or with a cement gun, possesses exceptional volume stability at temperatures up to 3100 F, and provides

[*Continued on page 192*]

Heating, Piping & Air Conditioning [9-48]
6 N. Michigan Ave., Chicago 2, Ill.

Please ask the manufacturers to send me more information about the equipment mentioned under the following reference numbers in Equipment Developments and Recent Trade Literature

(Circle each number in which your are interested)

3853 3854 3855 3856 3857 3858 3859 3860 3861 3862
3863 3864 3865 3866 3867 3868 3869
6961 6962 6963 6964 6965 6966 6967 6968 6969 6970
6971 6972 6973 6974 6975 6976 6977 6978 6979 6980
6981 6982 6983 6984 6985 6986 6987 6988 6989 6990
6991

Name ..... **Title**.....

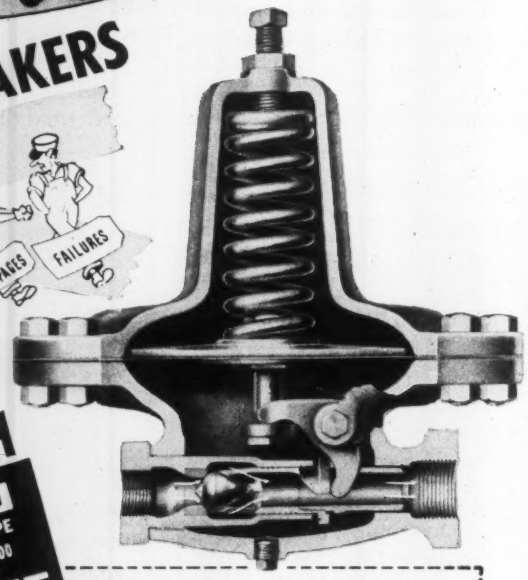
Company .....

Address .....

City ..... **Zone**.... **State**.....

IT'S GOODBYE Forever TO THESE TROUBLEMAKERS

IN PLANTS EQUIPPED WITH CASH STANDARD Streamlined PRESSURE REDUCING VALVES TYPE 1000



The Reasons Why IT HAPPENS ARE TOLD BY USERS AS FOLLOWS . . .

Check what the users say against the Benefit Points Below

• A Rubber Goods Manufacturer says—

"We have used these Type '1000' valves for several years with fine results on air or water service at pressures from 10 lb. to 300 lb. depending on requirements. These valves as claimed have been found to have **LARGE CAPACITIES.** On **FLUCTUATING LOADS** or **STEADY LOADS** they are **MOST DEPENDABLE, RAPID IN ACTION** with a **QUICK DEMAND** and **TIGHT CLOSING** when the load drops off. They require but a **MINIMUM OF SERVICE OR MAINTENANCE."**

• A Chemical manufacturer says—

"The CASH STANDARD Type '1000' valves which we have in service have fulfilled the conditions checked . . . **(ACCURATE PRESSURE CONTROL UNDER TOUGHEST WORKING CONDITIONS), (TROUBLE FREE SERVICE), (TIGHT CLOSURE)** better than any other steam pressure reducing valves that we have used."

• A Metal Products company says—

"We have had a number of your CASH STANDARD Type '1000' valves in operation in our plant for a number of years. These valves have proved to be satisfactory in every respect. We particularly like this type of valve because it is **SIMPLE TO INSTALL, REQUIRES A MINIMUM OF MAINTENANCE,** and gives **CONTINUOUS** and **UNIFORM PRESSURE CONTROL.**

• A Plant Engineer says—

"We find that the CASH STANDARD Type '1000' streamlined valves are best suited for our various applications of compression molding because of their **VERY WIDE RANGE OF ACCURATE PRESSURE CONTROL.** The simplicity of construction of these valves has kept the **MAINTENANCE COSTS VERY LOW** which of course means a **SAVING IN COST OF OPERATION,** and **SPEEDIER PRODUCTION.**

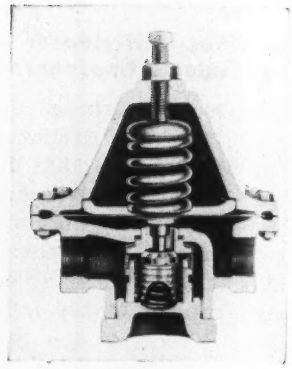
1. **Maximum capacity when needed most.**
2. **Accurate pressure control under toughest working conditions.**
3. **Trouble-free service.**
4. **Smooth operation.**
5. **Tight closure.**
6. **Speedier production results.**
7. **Elimination of failures.**
8. **Cost-saving operation.**
9. **No spoilage.**
10. **Practically zero in maintenance.**

WRITE FOR BULLETIN 962

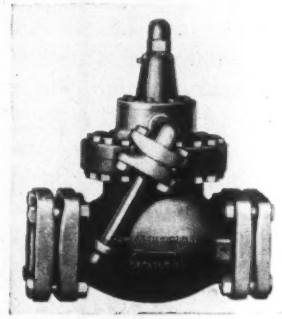
CASH STANDARD CONTROLS . . . VALVES

A. W. CASH COMPANY
DECATUR, ILLINOIS

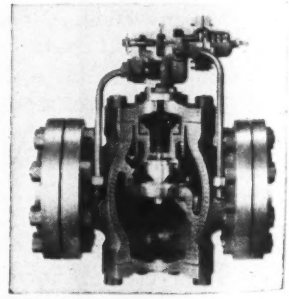
• **BULLETINS AVAILABLE ON OTHER CASH STANDARD VALVES** *Send for them* •



Bulletin 950—features the CASH STANDARD Type D Single Seat Pressure Reducing and Regulating Valves for use with most fluids. Shows simple inner working parts that save in maintenance. Diagram explains how valve works. Blueprint shows simplicity of installation.



Bulletin 956—features the CASH STANDARD Type 4030 Back Pressure Valve — designed to automatically maintain a constant pressure in the evaporator corresponding to a constant temperature desired. Shows an Ammonia and Freon Gas Capacity Chart based on ABSOLUTE pressures.



Bulletin 966—features the CASH STANDARD Self-Contained, Pilot Operated Type 10 Pressure Reducing and Regulating Valve for use with water or air; with any gas or oil that is non-corrosive; and with refrigerating fluids such as Ammonia and Freon. Many interesting particulars explained such as: how valve works, tight seating, large capacity, no waste, no water hammer or chatter.

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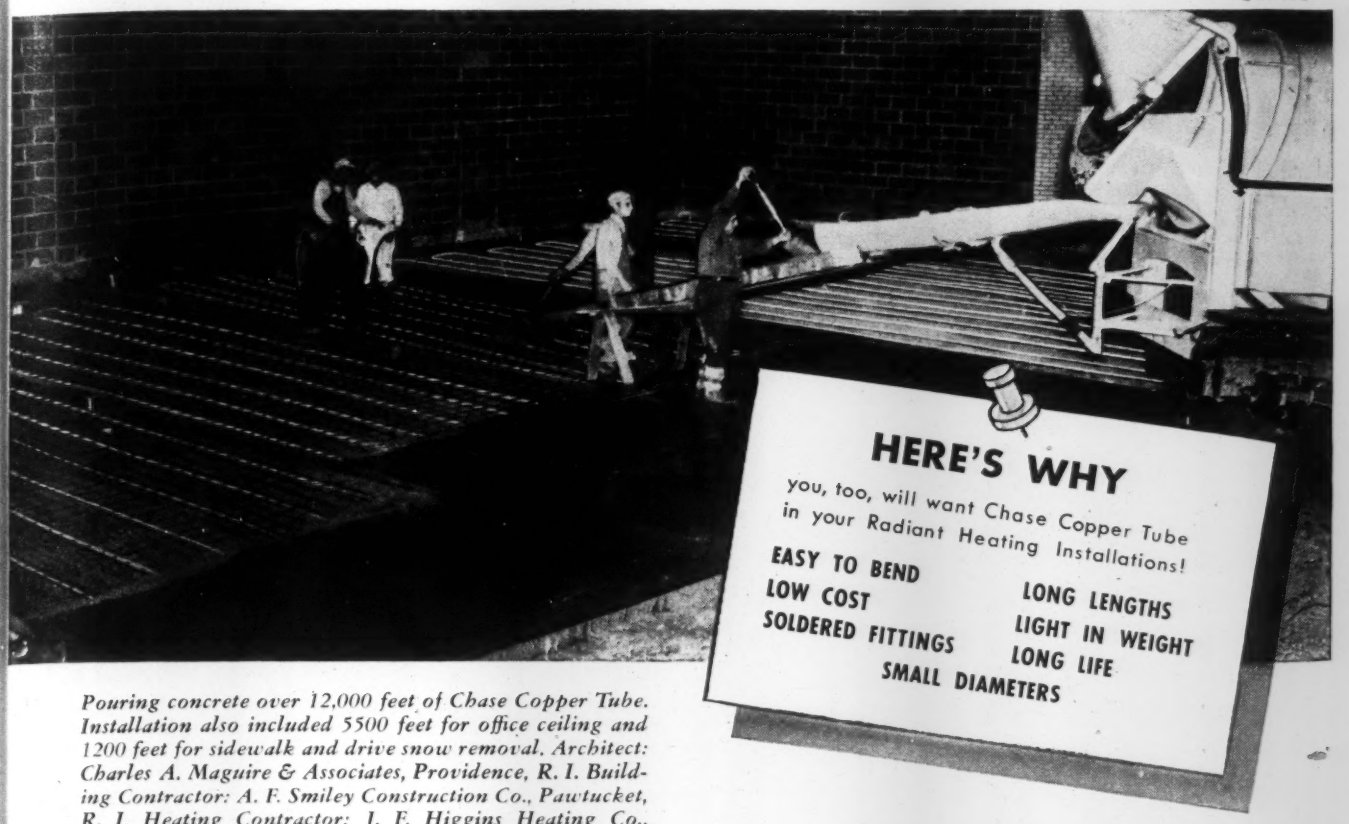
PROVIDENCE WAREHOUSE WITH 22,000 SQ. FT. FLOOR AREA USES CHASE COPPER TUBE FOR RADIANT HEATING!



Pouring concrete over 12,000 feet of Chase Copper Tube. Installation also included 5500 feet for office ceiling and 1200 feet for sidewalk and drive snow removal. Architect: Charles A. Maguire & Associates, Providence, R. I. Building Contractor: A. F. Smiley Construction Co., Pawtucket, R. I. Heating Contractor: J. F. Higgins Heating Co., Providence, R. I.

BIG jobs . . . little jobs, Chase Copper Tube has the advantages that mean fast, economical installation . . . dependability! For instance: you reduce costly, time-consuming connections because Chase Copper Tube is available in coils up to 100 feet long. Its flexibility means quick, easy hand-bending! And no fittings are needed at bends.

In floor installations, as illustrated, there's no need for accurate leveling of Chase Copper Tube. For ceilings, its light weight makes this overhead work easier . . . and its small diameter does not require extra plaster for coverage. Send for instructive, informative booklet that discusses radiant heating in theory and practice. Write Dept. HPA-98.

Send for **FREE** book "Suggestions for Designing RADIANT PANEL HEATING with Copper Tube."

MAIL THIS COUPON TODAY!

Chase Brass & Copper Co., Dept. HPA98
Waterbury 91, Conn.

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4 COMMERCIAL SIZES

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3 DOMESTIC MODELS — 104,000 to 261,000 BTU

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Firm____

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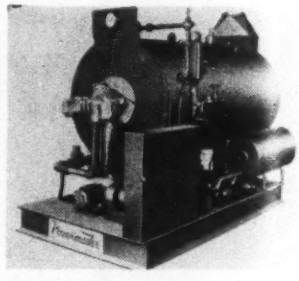
MT. HAWLEY MFG. CO.
MT. HAWLEY AIRPORT—1
PEORIA 4, ILLINOIS

[*Continued from page 187*]

protection against attack by fuel slags, metallurgical and chemical slags, molten materials, and other reactive products.

For use in furnaces where temperature and spalling conditions are less severe, the company has announced a second product, "Hydrochrome." This chrome base concrete has a temperature use limit of 2800 F and is recommended for the great majority of water cooled boiler furnaces and for metal processing furnaces with moderate operating temperatures.

Steam Generator Burns Light, Heavy Oil, or Gas



No. 3857—A new "Powermaster" steam generating unit for burning light oil, heavy oil, or gas has been developed by Orr & Sembower, Inc., Reading, Pa.

All three fuels are burned with the same burner, so that changeover from one fuel to another is said to be a matter of only a few minutes.

The manufacturer believes that the new packaged steam generating unit will be especially efficient and economical for heating or process steam use or for power generation in sections of the country where interruptible or offpeak gas service rates are in effect, as well as in any section experiencing an oil shortage.

The new unit ranges from 15 to 200 hp and is fully automatic. Advantages are said to include modulated control to maintain constant pressure as demand varies.

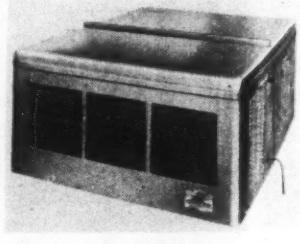
Industrial Air Vents Have Increased Capacity

No. 3858—Greatly increased air venting capacity is said to feature a new line of high pressure air vents for industrial steam equipment. Phosphor bronze helical bellows with relatively large diameters are designed to permit the use of oversize valve orifices at pressures from 0 to 200 psi. The manufacturer is Sarco Co., Inc., Empire State Bldg., New York 1, N. Y.

Incorporating renewable heads of stainless steel, bodies and bonnets of cast brass, cast iron, or semi-steel, depending on the size and pressure, the vents are available in vertical and angle patterns and in sizes from $\frac{3}{8}$ to $1\frac{1}{4}$ in.

They are recommended for installation on equipment such as steam jacketed kettles, calender beds, canning retorts, rotary dryers, large bucket type steam traps, etc.

Dual Refrigerating Units in Window Type Conditioner



No. 3859—A new window type room air conditioner, equipped with two separate refrigerating systems for "selective cooling" of the home or office, has been developed by Frigidaire Div., General Motors Corp., Dayton 1, Ohio.

The dual refrigerating systems, operated by two hermetically sealed, self oiling "Meter-Miser" compressors, are said to provide more than ¾ ton of refrigerating capacity. They can be operated together or separately, according to the dictates of outside temperatures. One of the systems is designed to supply adequate capacity to cool a room during the night and temperate summer weather. During extremely hot days both systems can be operated simultaneously. According to the company, rooms up to 500 sq ft in size can be air conditioned. The unit filters, dehumidifies, cools, and circulates air at the rate of 325 cfm. Fresh outside air for ventilation can be added at a rate of up to 50 cfm.

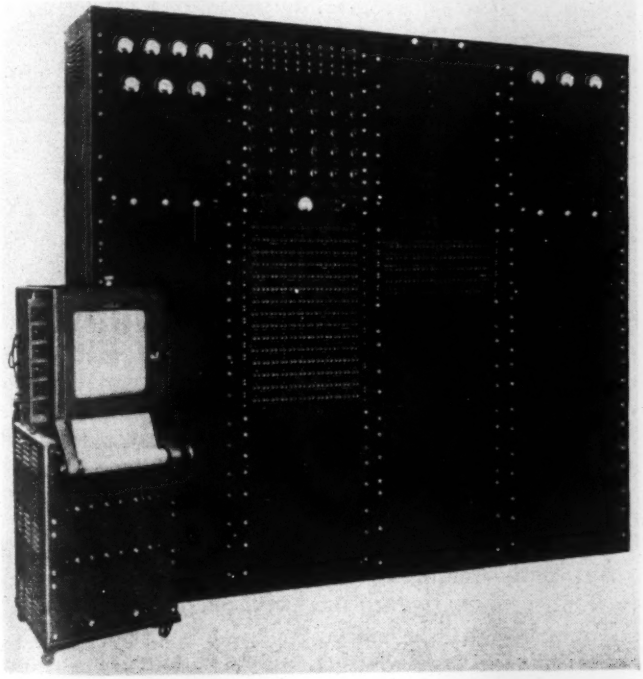
Two controls regulate the unit. A four position master switch controls the fan and cooling systems, and an adjustable fresh air control governs the amount of outside air brought into the unit. A thermostat control, available if desired, will provide automatic operation of one refrigerating system. Excess moisture is said to be evaporated or blown away by the fan so that plumbing connections are not necessary.

The conditioner operates on 230 volt, a-c current. Both the cooling and condensing fans are powered by a single 1/6 hp motor. A spun glass air filter is used.

Office Size Electronic Computer Solves Intricate Math Problems

No. 3860—An office size, electronic analog computer is now available from Reeves Instrument Corp., 215 E. 91st St., New York 28, N. Y. It is the result of the company's developmental work for the government and is now available to industry—since it has been removed from the Navy's list of confidential material.

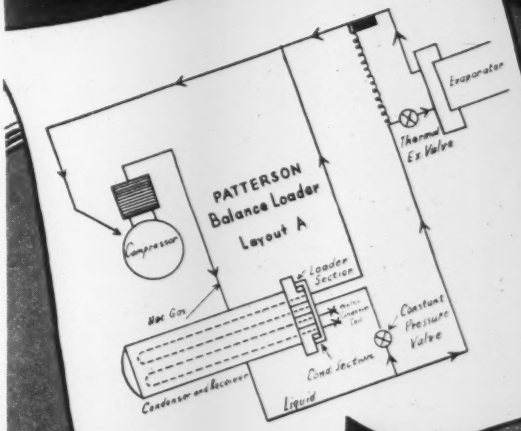
According to the company, it is a high speed, reasonably priced, differential analyzer which makes possible mathematical explorations into fields of scientific analysis that have formerly been economically unfeasible.



The manufacturer believes that it will find extensive use in many fields, including air conditioning and refrigeration—particularly in the solution and analysis of

PATTERSON

BALANCE-LOADER



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In writing for further details, give information on capacity and evaporator temperature desired and a description of the system, The Patterson Balance-Loader can be installed in existing systems.

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10 SALES CLINCHERS!

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1. **EXCLUSIVE ILG SELF-COOLED MOTOR**—No "slow-roasting" of motor due to radiated heat from core. Saves power cost.
2. **TWO-PIECE GRADUATED HEADER**—Gives you "Balanced" steam distribution . . . each tube expands and contracts uniformly.
3. **TOP OF HEADER**—Bolted on, using gasket tested by 60 years of steam practice . . . simplifies maintenance.
4. **BRASS ORIFICE BUSHINGS**—Expand tubes uniformly in header plate.
5. **SOLID COPPER CORE**—26 gauge flanged copper fins pressed onto ½" O. D. copper round tubes.
6. **BOTTOM HEADER**—"Floats" on slotted coil retainer and spring washers . . . permits expansion and contraction of coil independent of unit casing.
7. **DYNAMIC HEAT DISTRIBUTION**—Individually adjustable louvers lessen air turbulence and increase heating range.
8. **SAFETY SUSPENSION**—Sturdy eyebolts, connected directly to rugged cast-iron header, remove all weight from supply line.
9. **DYNAMICALLY BALANCED FAN WHEEL**—Specially designed for ILG Unit Heaters. Verified for dynamic balance at rated speeds.
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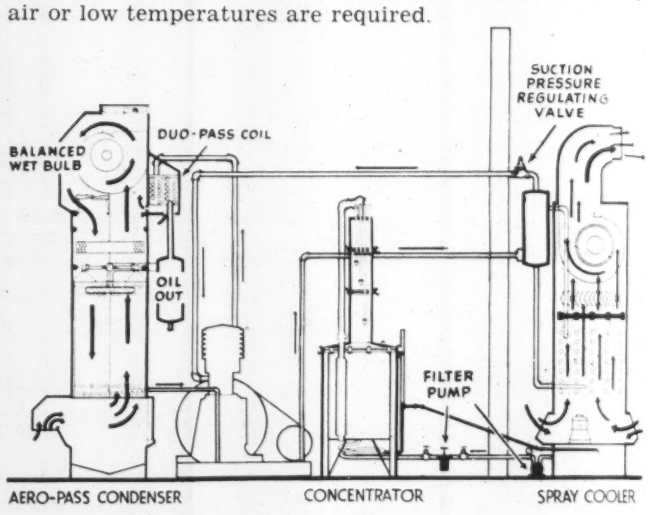
heat flow, control, and all other problems requiring the dynamic solution of simultaneous differential equations.

As a simulator it may be operated to actually simulate a system such as a temperature control or fuel flow control system so as to evaluate the allowable range of design parameters. It may also be used to check model systems to determine whether they will meet actual field conditions. In addition, it is also said to solve, with a high degree of accuracy, any initial valued differential equation up to the seventh order. A servo mechanism unit may be added to provide for vector resolution and vector addition. The computer will multiply and divide arbitrary functions.

Refrigeration Equipment Designed to Eliminate Frost on Coils

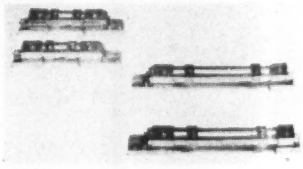
No. 3861—Niagara Blower Co., 405 Lexington Ave., New York 17, N. Y., has improved the design and construction of equipment used in its "No-Frost" method of refrigeration. Because it is designed to chill air below the freezing point of water without permitting the formation of frost or ice on the coils, it is said to be especially suitable for processes where interruptions might impair quality or limit production. It is also used in air conditioning and processes where extremely dry air or low temperatures are required.



Equipment consists of a fan spray cooler which chills the air and distributes it, a concentrator designed to maintain the proper concentration of special liquid, an "Aeropass" condenser, and a compressor which may be any make selected by the user.

Air is chilled by contact with the coils and a recirculating cold spray of the special liquid. As moisture is condensed from the air stream the solution becomes diluted. The excess water, however, is evaporated in the concentrator. Component units are built in a range of sizes from 10 tons up.

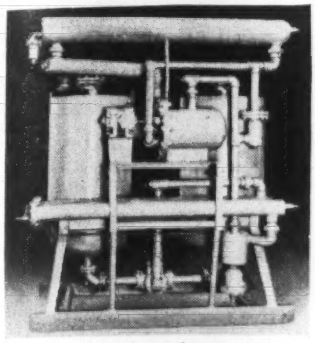
Adjustability, Rigidity Feature Fan and Motor Base



No. 3862—Complete adjustability and rigidity is possible in fan and motor installations with the "Duplex" twin rail base, according to Korfund Co., Inc., 48-36 Thirty-Second Pl., Long Island City 1, N. Y.

The separate base construction is said to be made practical by the use of resilient "Adjusto-Chocks" which are designed to maintain positive alignment. For the first time, says the company, final selection of drive center distance, motor position, fan rotation, and hold-down bolt location can be determined on the job. Other advantages are said to include the fact that the base will often accommodate complete changes in fans and motors.

Dries Instrument Air



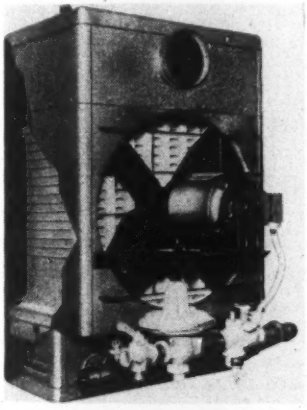
No. 3863—Pittsburgh Lectrodryer Corp., P.O. Box 1766, Pittsburgh 30, Pa., is producing a new line of solid adsorption dehumidifying machines primarily designed for drying instrument air.

Built in accordance with ASME code requirements, they are known as the BY line of "Lectrodryers."

Features are said to include small space requirements and more economical operation, as compared to previous models. Units are built as standard for operation on pressures up to 150 psig with the purchaser given the option of either steam or electric reactivation. Machines for operation at higher pressures are available on specification. Standard sizes range up to 5000 cfm.

The machines are said to be especially suitable for drying compressed air used for control apparatus.

Cast Iron Construction Used in Gas Unit Heater

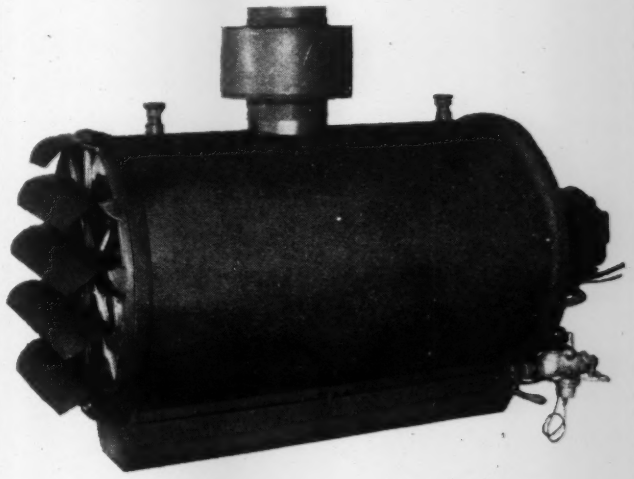


No. 3864—A new line of gas fired unit heaters, featuring cast iron construction in both the heat exchanger and the combustion chamber, has been placed on the market by Automatic Gas Equipment Co., 301 Bruston Ave., Pittsburgh 21, Pa. The heat exchanger and combustion chamber are cast in one piece and the extended heating surface fins on the exchanger are cast integral.

Designated as series C, the heaters incorporate a built-in draft hood and a safety pilot. According to the manufacturer, they have been approved by the American Gas Association.

Bronze Construction and Stainless Shaft Feature Turbine Type Pump

No. 3865**—Roy E. Roth Co., Rock Island, Ill., has developed a low cost turbine type pump for liquid transfer. Known as the model 0023, this pump is said to be suitable for numerous industrial applications and to furnish pressures up to 80 psi while providing a flow of 8 gpm. It is designed to operate at speeds up to 2200 rpm.



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John Zink Company

4401 South Peoria

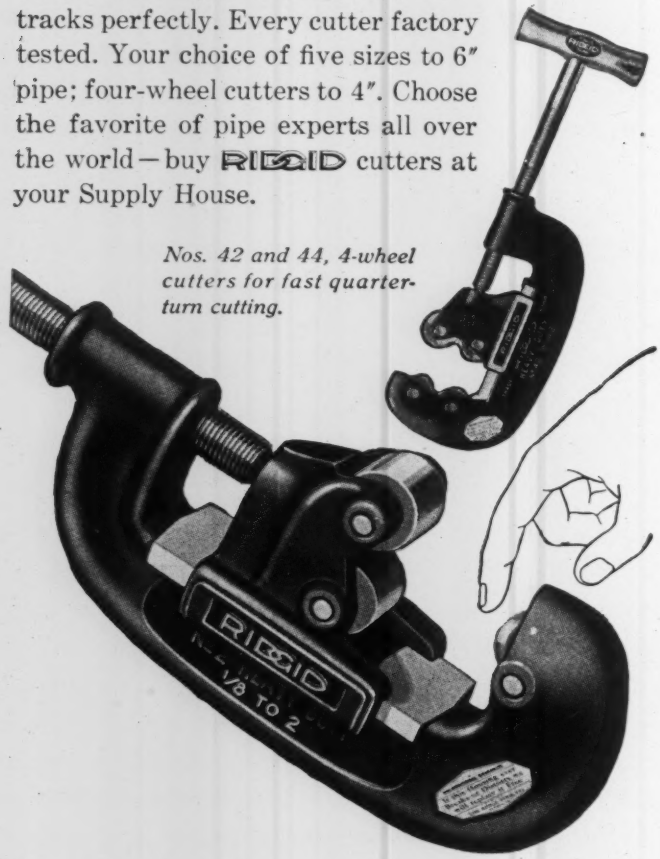
TULSA, OKLAHOMA

New York - Salt Lake City - Houston - Los Angeles

MORE QUICK CLEAN *Pipe Cuts* FOR YOUR MONEY

RIDGID Cutter with thin blade wheel rolls easily through all kinds of pipe

● It's a cinch to cut pipe extra fast with the new efficiency-balanced RIDGID cutter. Extra cutting power comes from the heat-treated tool-steel blade; tough and thin, it rolls easily through any kind of pipe—leaves practically no burr—tracks perfectly. Every cutter factory tested. Your choice of five sizes to 6" pipe; four-wheel cutters to 4". Choose the favorite of pipe experts all over the world—buy RIDGID cutters at your Supply House.

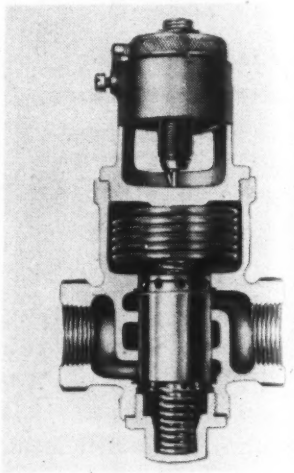


Nos. 42 and 44, 4-wheel cutters for fast quarter-turn cutting.

RIDGID
WORK-SAVER PIPE TOOLS
THE RIDGE TOOL COMPANY • ELYRIA, OHIO

This single stage pump is all bronze with a stainless steel shaft and double ball bearings. The single multi-vaned impeller, which is the only moving part of this pump, is designed to handle condensate without vapor binding.

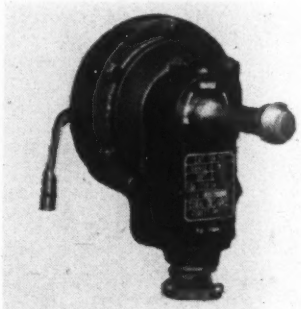
Controls Water Temperature



No. 3866—A water tempering controller which is designed to maintain a constant, predetermined water temperature at its outlet—regardless of heater tank or tankless heater temperature variations—has been announced by Symmons Engineering Co., 791 Tremont St., Boston 18.

Actuated by a solid filled bellows which is mounted out of the water in a protected chamber open to the atmosphere, the valve may be installed anywhere along the line and is said to automatically compensate for normal pressure fluctuations. The device may be set for any desired temperature between 100 and 170 F. It is available in the ¾ in. size with a capacity of approximately 20 gpm at 50 psi and also in the 1 in. size with a capacity of approximately 35 gpm at 50 psi. It is recommended by the manufacturer for many commercial applications and where scalding water is necessary at some outlets but undesirable at others.

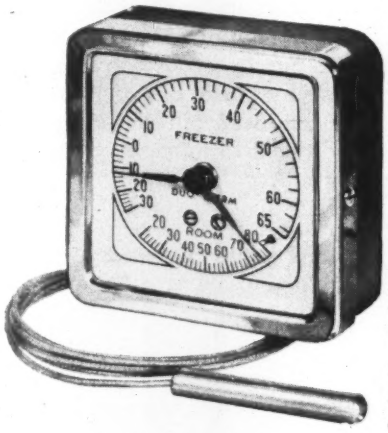
Regulates Static Pressure



No. 3867**—The Cat. 101 static pressure controls are for applications on low pressures where regulation is required in inches of water, either pressure or vacuum. According to the manufacturer, Coral Designs, P.O. Box 248, Forest Hills, N. Y., they have numerous applications in air conditioning and heating, where it is necessary that a circuit be controlled either from the suction or exhaust side of the fan, and, in event of fan failure, auxiliary equipment will be shut down. They are also recommended for air conditioning use in connection with reversing type damper control motors to prevent discharge of air into individual zones at excessively high velocities. Likewise, they may be employed for combustion control when used in connection with reversing type damper control motors.

Units are obtainable in standard ratings ranging from 0 to 20 in. water pressure or vacuum and with range adjustment. Fixed differentials are from 0.2 to 2 in. water. Units are available with a double throw circuit or floating contacts for use in connection with reversing type damper control motors.

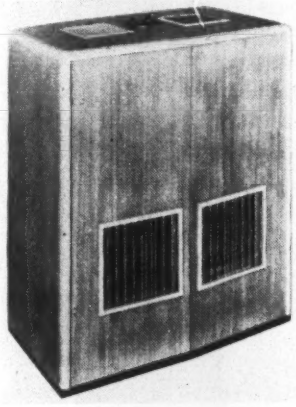
Thermometer Indicates Two Temperatures



No. 3868—The Jas. P. Marsh Corp. (Dept. 13-N), Skokie, Ill., is offering a "Duo-Therm" dual purpose thermometer for use in connection with refrigeration units of all kinds.

The instrument contains two thermometers which are combined to indicate room temperature and a lower temperature. One thermometer shows temperatures from —30 to 65 F, is a distant reading Bourdon tube type, and has 5 ft of capillary tubing. The other thermometer is of the bimetallic type and indicates temperatures from 20 to 80 F.

Room Cooler Has Hermetic Unit



No. 3869 — The newest console type room cooler offered by United States Air Conditioning Corp., 33rd & Como Ave., S.E., Minneapolis 14, Minn., has a water cooled refrigerating unit.

Housed in either a blond or dark mahogany wood cabinet, the unit is designed to cool, dehumidify, filter, and circulate room air. A new hermetically sealed compressor-motor unit is used and two sizes are available—¾ and 1 ton.

According to the company, water consumption is held to minimum by a new condensing coil design. "Freon" is the refrigerant used.

Equipment Shorts

A training school for technicians and apprentice mechanics from branch offices as well as June graduates in mechanical engineering from various colleges was conducted last month by Johnson Service Co., Milwaukee. Under the direction of J. R. Vernon, sales promotion manager, the course was divided into three sections: automatic control apparatus, heating and air conditioning systems, and sales and contracting operations.

Cutler-Hammer, Inc., Milwaukee, has acquired the business of the West Electric Products Co., Los Angeles. W. G. Tapping, district sales manager, will be in charge of the new plant which will be integrated with other company plants in the manufacture of motor controls, panelboards, lifting magnets, magnetic brakes, electric heating devices, and allied electric apparatus. Operating personnel of West Electric Products Co. is being retained.

EXTRA EASY
Threading
OF SMALL PIPE

RIDGID 00R Ratchet Threaders
give quick, clean threads on ⅛" to 2" pipe

● No bothersome get-ready with these handy little RIDGID Threaders. Just snap in size die head you need and go to work. Even on close-to-wall threads there's no fuss or trouble—no extra dies required. These RIDGID Threaders make it easy to get clean, quick threads on all kinds of small pipe. Sturdy steel and malleable construction—long life heat-treated tool-steel dies. No. 00R ⅛" to 1" pipe; No. 111R, ⅛" to 1¼"; No. 12R ⅛" to 2". Buy them at your Supply House.

Free handy carrier for any group of sizes.

RIDGID
WORK-SAVER PIPE TOOLS
THE RIDGE TOOL COMPANY • ELYRIA, OHIO

BARBER COLMAN

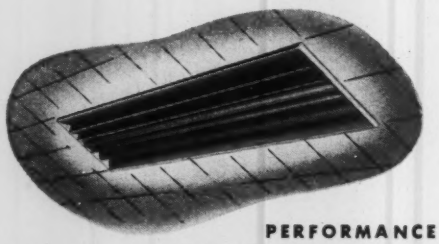
Line-O-Flo

CEILING OUTLETS

These new line-type ceiling outlets can be used singly or end-to-end in continuous strips. They are constructed of scientifically-designed, rolled-steel members all dimensionally coordinated for use with acoustical ceilings and other building products.

A New Approach to Air Distribution

Keyed to modern architectural concepts, LINE-O-FLO, provides a vital contribution to continuity of design. High diffusion efficiency results in rapid induction of room air into the primary stream, quickly equalizing the temperature differential.



PERFORMANCE DATA ASSURES ACCURATE ENGINEERING

Knowing the CFM available and the throw required, the number of standard units needed can be quickly obtained from reliable Performance Data tables. Two basic models are made — Model "LS" (shown above) and Model "LL" (designed to receive M21118 DAY-BRITE Lighting Unit).

Ask for Bulletin F-2741 and get full performance data, dimensions, description, principles of operation, typical installation methods, and suggested uses. Write today.

BARBER-COLMAN COMPANY
1228 ROCK ST. • ROCKFORD, ILLINOIS

Equipment Shorts (Cont.)

Dravo Corp., Neville Island, Pittsburgh, has completed transfer of its city offices to the Pitt Bank Bldg., Fifth and Liberty Aves. The 12 story building, one of Pittsburgh's first skyscrapers, was purchased by the corporation last year and has been renamed Dravo Building. The former Dravo Building has been purchased by the state and eventually will be razed to make way for the Point Park development.

In line with its "Champion" series of national trade advertisements which is featuring the late Babe Ruth, Wheatland Tube Co., Philadelphia, has presented a contribution to the Babe Ruth Foundation.

Beginning this month, General Engineering & Mfg. Co., St. Louis, will hold a series of 10 regional sales meetings. Leading off with a two day session in St. Louis, production and sales plans for the coming year will be discussed with the entire distributor organization. The other meetings will be held in various cities throughout the country.

Star Tubular Products Co., 4747 S. Richmond St., Chicago, has recently been formed and has purchased the assets and facilities of the Star Nipple Co. at the same Chicago address. The new company will produce a complete line of pipe nipples and will also prefabricate tubular products. W. D. Reed is president and Richard L. Kopp is secretary.

More than 800 dealers in the east and midwest attended a recent series of four meetings at which the new line of "York Heat" products was presented and a merchandising program for the year outlined. The new products, offered by York-Shipley, York, Pa., include a boiler unit for radiant heating, tubeless boiler units, water heaters, and a winter air conditioning unit.

A western sales division with headquarters at Pasadena, Calif., has been established by the Schaible Co., manufacturer of fittings and valves. The new division will serve 10 Pacific coast and Rocky Mountain states. Also newly established is an export department which will handle sales by overseas representatives. Now included in the company's expanded line are air and vacuum valves, hot water and steam radiator valves, union elbows, automatic regulators, and relief valves.

A new and improved type of "Chromalox" infrared electric radiant heaters has been developed by Edwin L. Wiegand Co., 7610 Thomas Blvd., Pittsburgh 8, Pa. Inconel sheathed tubular heating units operate at temperatures from 1000 to 1400 F, depending on the wattage of the element which is mounted at the focus of a parabolic reflecting surface. According to the company, a negligible amount of visible light is produced, and the glassless construction is said to make the unit ideal for use with conveyor belts. The heaters are recommended for any drying, heating, baking, or dehydrating job where radiant heat is desired.

UNIVERSITY OF MICHIGAN LIBRARIES

EXECUTIVE CHANGES

Carroll M. Baumgardner has announced his resignation as executive vice president and member of the board of directors of United States Radiator Corp., Detroit. He has also resigned as president and member of the board of directors of the Capitol Finance Corp., Detroit.

Frank S. Kaulback, vice president and general manager of branches of American Radiator & Standard Sanitary Corp., has retired from active service in accordance with the company's retirement plan. He is succeeded by Robert W. Lang, supervisor of the central division of the American-Standard branch house department, who has been elected vice president and general manager of branches.

James W. May is now technical director of the air filter div., American Air Filter Co., Inc., Louisville. Before joining the company in 1943, as director of research, he was associate professor of heating, ventilating, and air conditioning at the University of Kentucky.

The board of directors of Petroleum Heat and Power Co., Stamford, Conn., has elected James D. Burnes vice president and general manager. He has been treasurer since 1945 and was elected a vice president in 1947. Thomas J. Cody, comptroller since 1947, has succeeded Mr. Burnes as treasurer.

John H. Bartol, formerly passenger sales supervisor, American Air Lines, has joined the W. B. Connor Engineering Corp. as director of its air recovery division.

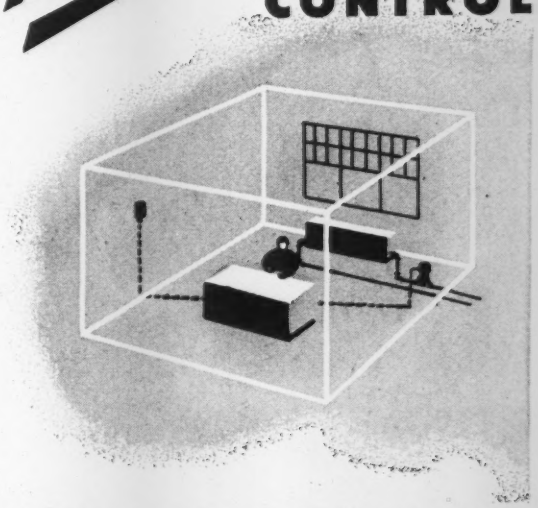
Benjamin T. Hain has been named general manager for manufacturing by the National Radiator Co., Johnstown, Pa. He is in charge of all manufacturing activities at the company's plants.

Chester Morrison has been appointed director of foreign operations of York Corp., York, Pa. John Carr, who has been appointed manager of the company's international division, will assist Mr. Morrison. Both men have been with the company many years and have served in the foreign field.

The new head of the department of mechanical engineering at Illinois Institute of Technology is Dr. Frank D. Carvin. The appointment became effective the first of this month when James C. Peebles, dean of engineering, retired and Dr. John T. Rettaliata, former head of mechanical engineering, became dean. Dr. Carvin had been head of mechanical engineering and chairman of the graduate division at Newark College of Engineering.

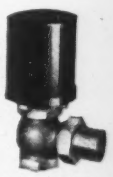
BARBER COLMAN

Individual ROOM CONTROL

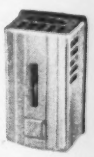


SATISFIES OCCUPANT'S PREFERENCES....

Here is a sure way to keep everyone satisfied . . . to meet the personal preference as to room temperature. Individual Room Control — a Motor-Operated Valve on the radiator, controlled by a thermostat *in the same* room gives each occupant the chance to enjoy a chosen degree of warmth. Installation is easy . . . valves come Completely assembled, *low voltage* wiring is economically installed in new or existing buildings.



Packless Radiator Valve for low Pressure Steam



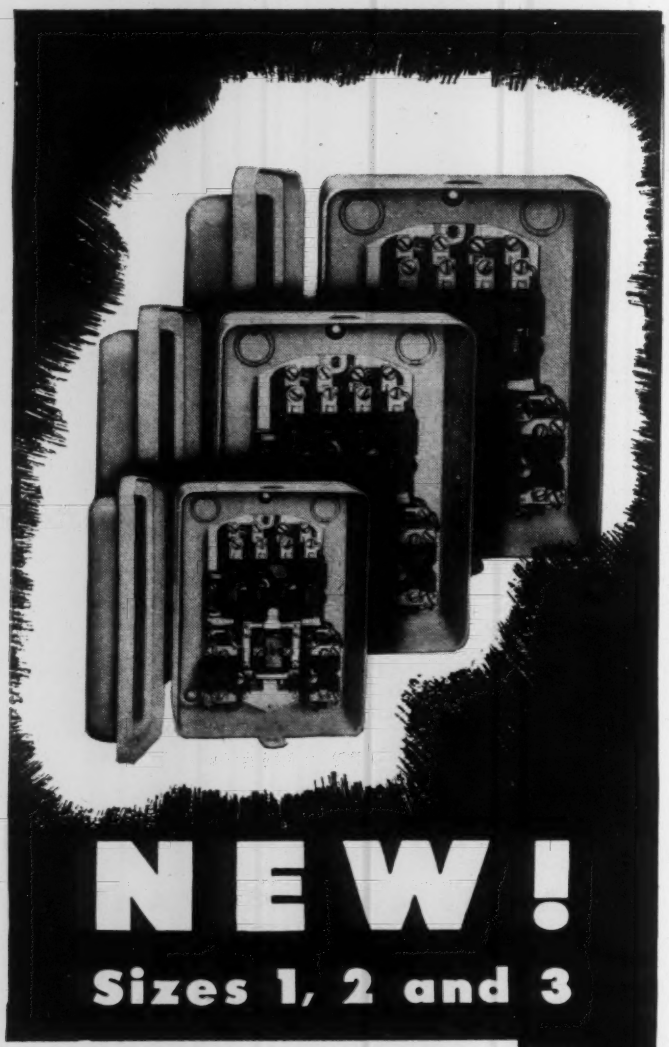
Standard Low Voltage Room Thermostat

For

OFFICES • HOTELS • HOSPITALS SCHOOLS • CHURCHES • INSTITUTIONS

The system can be installed room by room, in parts of the structure, or in the whole building as maintenance budgets may permit. Individual Room Control offers important overall economy and savings of fuel. For specific suggestions consult your Barber-Colman representative, or write direct to us.

BARBER-COLMAN COMPANY
1228 ROCK ST. • ROCKFORD, ILLINOIS



NEW!

Sizes 1, 2 and 3

Ward Leonard a-c Magnetic Starter Is Small in Size, Big in Performance

For fast, positive, dependable across-the-line starting of non-reversing motors, install Ward Leonard 4110 a-c Magnetic Starters.

Unit construction. Open or enclosed type. Accessible components. Double-break silver-to-silver main contacts. Thermal relays give overload protection. Local or remote control.

Ward Leonard Starters are "Result-Engineered." By modifying a basic design, Ward Leonard can give you the results of a special . . . for the cost of a standard.

Write for Bulletin 4110. Ward Leonard Electric Co., 24 South St., Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WHERE BASIC DESIGNS IN ELECTRIC CONTROLS ARE RESULT-ENGINEERED FOR YOU

WARD LEONARD ELECTRIC COMPANY

RESISTORS · RHEOSTATS · RELAYS · CONTROL DEVICES

NEW BOOKS & REPORTS

Valuable Pump Text Includes Theory, Practical Considerations

Centrifugal and Axial Flow Pumps, by A. J. Stepanoff, Ingersoll-Rand Co., opens with a profound mathematical study of the historical background for design of both radial flow and axial flow pumps. Emphasis is placed on the essential incompressibility of the material to be handled.

The earlier chapters are of particular value to young mathematical wizards who propose to design new apparatuses for transporting liquids. The data and the references, which latter are opulent, would do no harm even to a designer of gas handling machines.

The treatise is meticulous in its formulas and equations for solving mathematically the design of runners, casings, shafts, glands, and approach aspects for both radial and axial flow pumps. Design lore is included as to the shape of every part of a pump that "sees" the liquid, and the airfoil influences, turbulence, pre-inlet rotation, and other matters are discussed thoroughly.

There are hundreds of diagrams and sketches, usually located adjacent to the descriptive matter, though there are a few aggravating instances that require search for illustrations through earlier or later chapters.

The book becomes more interesting to the ordinary reader when, following voluminous theoretical computations, multistage pumps, as for very high pressures, and deep well pumps, with their successive vertical stages, are discussed.

There is constant reference to the analogy of the water wheel, and the description of low head pumps, as for irrigation, would please any farmer.

The author is to be commended for emphasis on the importance of approach and discharge pipe aspect, as evidenced by the ratio of liquid delivered to the power input.

There is much valuable information concerning operating experiences and the influence of thrust balancing, shaft seals, and various types of bearings. Causes and suggested cures are given for vibration, noise, and pitting due to cavitation. Measures to protect pumps from improper rotation are explained.

One is impressed, on reading this book, with memories of bygone pump troubles which were perplexing at the time but which could have been solved quickly had this book been available.

It is evident that the author, aside from having combed the world's literature on pumps, also has a practical background of experience.

I am proud to have Dr. Stepanoff's book in my library and I recommend it to every engineer.

Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York City, this 428 page (6 x 9¼ in.) text is cloth-bound and is priced at $7.50 in this country, $9.00 in Canada.—Reviewed by Samuel R. Lewis, consulting engineer and member of HPAC's board of consulting and contributing editors.

UNIVERSITY OF MICHIGAN LIBRARIES

Molybdenum-Vanadium Pipe Material Shows Superior Long-Time Strength

Molybdenum-vanadium pipe material has superior long-time strength at high temperatures when compared to low chromium-molybdenum compositions. Furthermore, long time soaking of molybdenum-vanadium compositions has so far failed to show graphite formation. These conclusions are contained in a report, Some 1000 F Steam Pipe Materials, by Ernest L. Robinson, structural engineer, turbine generator engineering div., General Electric Co. The paper, which was presented at the last annual meeting of the American Society of Mechanical Engineers, gives long-time creep and rupture test results on materials suitable for high temperature steam piping. The series of tests were neither planned nor run at the same time, each series being a unit in itself. The group was selected from results, mostly unpublished, and is presented in a form suitable for guidance in design and for a basis of comparison between different compositions. The author suggests that these results be compared with similar results obtained elsewhere.

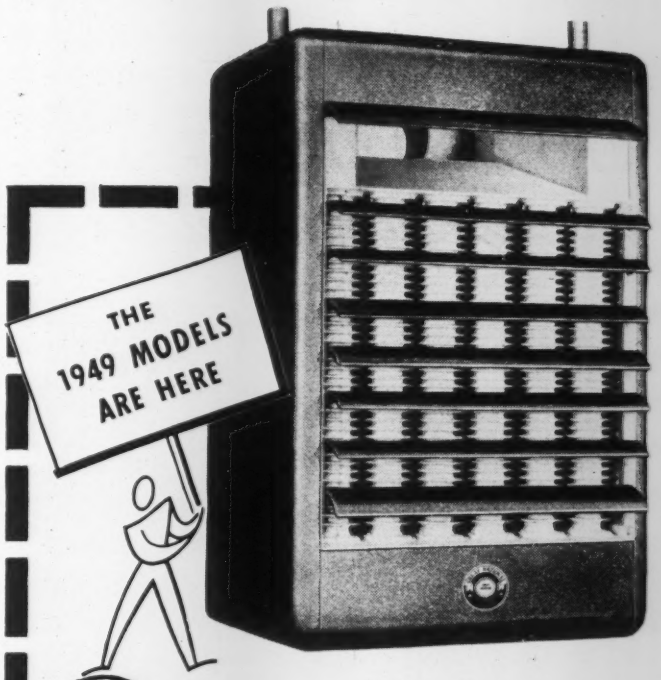
The paper, giving the results of six series of tests, has been reprinted by the Apparatus Dept., General Electric Co., Schenectady, N. Y.

Other Books and Reports

1948 National Wage Chart, published by the Builders Association of Chicago, 228 N. La Salle St., Chicago 1, $1.50 per copy. The chart, which has been issued by the association since 1902, shows the hourly wage rates being paid building mechanics in principal cities of the United States and Canada.

The Free Surface Around, and Interference Between, Gravity Wells, by H. E. Babbitt and D. H. Caldwell, respectively professor of sanitary engineering and formerly research assistant in civil engineering, University of Illinois. Designated as Bulletin Series No. 374, the report is published by the University of Illinois Engineering Experiment Station, Urbana, Ill., and is priced at 50 cents. The locus of points on the free surface of water surrounding a gravity well during pumping was found, by electrical analogy, in the laboratory and was checked by observations on a large scale model. Much of the report substantiates hypotheses and studies presented by other investigators.

Supplement to ASTM Standards—To keep up to date the triennially published book of ASTM standards, the American Society for Testing Materials, 1916 Race St., Philadelphia 3, issues supplements (in the intervening year) for each part of the book. The 1947 supplements, issued in five parts, cover some 330 odd specifications, tests, and definitions which were either issued for the first time last year or have been revised since the 1946 supplements were released. Paper covered copies are $4 per part, or all five parts for $20. Chemical analyses of metals are not included but are published in a special volume.



3 NEW GREAT NATIONAL GAS-FIRED UNIT HEATERS

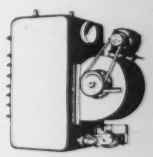
The big 1947-48 news in gas-fired unit heaters was the new Great National line. Now that line has been improved with four basic engineering advances, and enlarged to include new models, new sizes, and new styles.

The response to Great National's 1947-48 line proved what we had suspected: that there was a real need for a line of superbly-designed, well-engineered heaters. The 1948 Great National heaters are now far out in front—easily the quietest, most trouble-free, and most economical heaters of their kind on the market.

Write for the name of your nearest Great National dealer. Your worries about gas-fired heating will end the day he calls on you.

FAN TYPE

DUCT TYPE


BLOWER TYPE

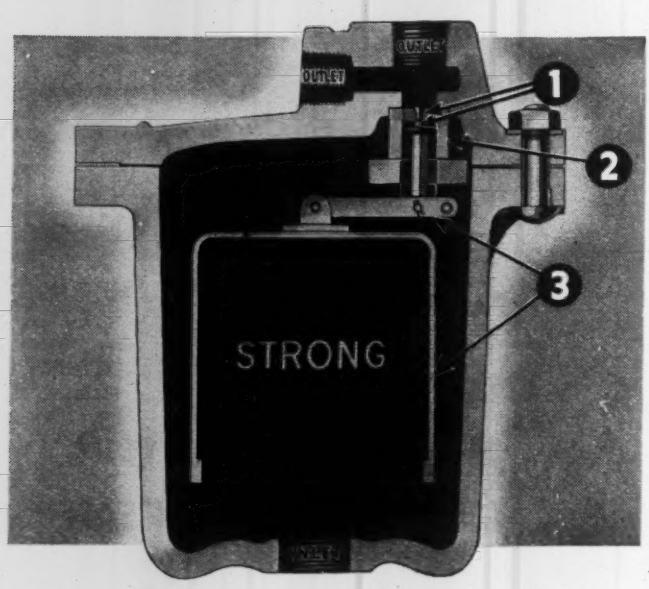
All three models available in four sizes: 100,000; 135,000; 200,000 and 270,000 BTU per hour. All styles available in both cast iron with 1% chromium, and in sheet metal.

Several good distributorship franchises are still available.

GREAT HEATERS NATIONAL

Great National Air Conditioning Co.
2146 North Harwood, Dallas, Texas
"Weathercrafters to the Nation"

3 Reasons STRONG* Traps are easy to maintain!



Look for these three STRONG low-maintenance features in the STRONG 80 Series Inverted Bucket Trap:

1. **Anum-Metl Valve and Seat—guaranteed leakproof for one year;**
2. **Bolted-in seat design—insures tight seal, easy servicing;**
3. **Stainless steel bucket and trim.**

Compare these features with other traps!

STRONG 80 Series Trap sizes ½" to 2½", pressures to 250 lbs., temperature to 500° F. (forged steel for higher pressures).

Dual outlet simplifies piping, bottom inlet keeps trap cleaner. Years of trouble-free operation assured by super-STRONG construction.

Catalog No. 67 describes inverted, open bucket and other types of STRONG traps. Write today.

*Trade Mark Reg. U. S. Pat. Off

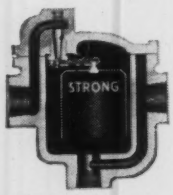
STRONG, CARLISLE & HAMMOND COMPANY
1392 West 3rd Street
Cleveland 13, Ohio

REG. TRADE MARK

ANUM-METL Reg. Trade Mark

OTHER STRONG STEAM SPECIALTIES

Reducing Valve



70 Series Trap

Strainer

STRONG

MEETINGS & CONVENTIONS

The Third National Instrument Conference and Exhibit—sponsored by the Instrument Society of America, 117 Wolfendale St., Pittsburgh 22, Pa. To be held September 13 to 17, Philadelphia Convention Hall.

The technical sessions will be devoted to virtually all phases of instrumentation. Papers to be presented will deal with ordnance instruments, temperature and pressure elements, automatic control, control valves, process control, and electronics.

In conjunction with the conference and exhibit, a number of short courses on electrical measurements and industrial instruments will be offered at Convention Hall under the direction of E. D. Wilson, head, chemical engineering department, Worcester Polytechnical Institute.

Illinois State Association of the Refrigeration Service Engineers Society—11th annual convention, September 25 and 26, St. Nicholas hotel, Springfield, Ill. Association secretary is B. V. Clark, 612 N. May St., Aurora, Ill.

Association of Iron and Steel Engineers—Air conditioning of crane cabs will be the subject of a talk to be given by R. D. Darrah, Dravo Corp., Pittsburgh, at the association's convention, September 28 to October 1 Cleveland. The talk will be given during the morning session on September 28.

American Gas Association, 420 Lexington Ave., New York City—1948 convention, October 4 to 8, Atlantic City.

Those planning to attend are urged to make reservations immediately. Application forms for hotel accommodations are available from association headquarters and should be filed with the AGA housing bureau, 16 Central Pier, Atlantic City, N. J.

Many industry-wide problems will be discussed at the general sessions, and sectional programs will delve into all phases of the gas business. The technical section meetings will be devoted to many subjects including synthetic liquid fuels, developments in a newly constructed catalytic cracking plant, uses of LP gases, mains and services, and modernizing existing plants to increase capacity.

The First Eastern Refrigeration and Air Conditioning Educational Exhibit and Conference—held in conjunction with the annual convention of the New England States Association, Refrigeration Service Engineers Society. This affair will be held October 8 to 10 at the Hotel Bradford, Boston, and is sponsored jointly by the Refrigeration Equipment Manufacturers Association and the RSES.

American Chemical Society, Chicago section, 1505 S. Wabash Ave., Chicago 5—Fifth National Chemical Ex-

One of a series of messages to help you increase your understanding of business paper advertising, and its effect on your business.

What happens when the "push-overs" start pushing back?

ASK ANY GOOD SALESMAN, and he'll tell you that the lush days are just about gone—along with shortages, slow production and the sellers' market.

Today, customers are playing hard to get. The "push-overs" are beginning to push back. Production isn't lagging any more—it's already nearly double the pre-war level, and fast catching up with demand. There's plenty of healthy competition in sight. And you can be glad there is.

American business has always thrived on competition. It still can. But the machinery of selling and distribution will have to work at peak efficiency.

And that means—*more mechanization!*

Mechanization is simply the application of assembly-line methods to the *manufacture of a sale.* It's the only way to balance mass production.

With mechanized selling, you won't turn prospects into "push-overs," but you'll certainly get them leaning your way. By exploring the field, arousing interest, creating a preference for the things your company makes, mechanized selling multiplies the productivity capacity of your sales force by the hundreds, or thousands, or by any number your market requires.

But this machine is no stranger to *you.* You know it by its first name—ADVERTISING.

We'd just like to point out that now is the time to put the machine to work, more consistently, more aggressively than ever. And remember that when your advertising goes to work in the right business papers, with their tremendous concentration of hand-picked readers, it becomes *the most efficient machine* you can use for manufacturing sales at a profit.

Just how efficiently does business paper advertising work? If you'd like to see some examples, we'll be glad to send you a recent ABP folder on actual results. Also, if you'd like reprints of this advertisement (or the entire series) to show to others in your organization, you may have them for the asking.

Heating, Piping & Air Conditioning

is one of the 129 members of The Associated Business Papers, whose chief purpose is to maintain the highest standards of editorial helpfulness—for the benefit of reader and advertiser alike.

position, October 12 through 16, Chicago Coliseum.

Plans for this show include the revival of the National Industrial Chemical Conference, which was not scheduled at the last show held in 1946.

According to Dr. L. E. Clifcorn, chairman of the exposition committee, "the conference will feature noted speakers who will present interesting papers on new developments, discoveries, and applications in industrial chemistry." Sessions will be held in the Coliseum Annex, under the same roof with the show, and all show visitors are welcome to attend the conference.

National Association of Housing Officials, 1313 E. 60th St., Chicago 37—annual meeting. October 13-16, Olympic hotel, Seattle. The Third Annual Exhibit of Building and Maintenance Products will be held concurrently.

National Institute of Governmental Purchasing—third annual conference and exhibit, October 18 to 20, Bellevue-Stratford hotel, Philadelphia. President W. Z. Betts, director of the division of purchase and contract, State of North Carolina, will be assisted by a committee of governmental buyers and a committee from the ranks of exhibitors. Executive director of the institute is A. H. Hall, 730 Jackson Pl., N.W., Washington 6, D. C.

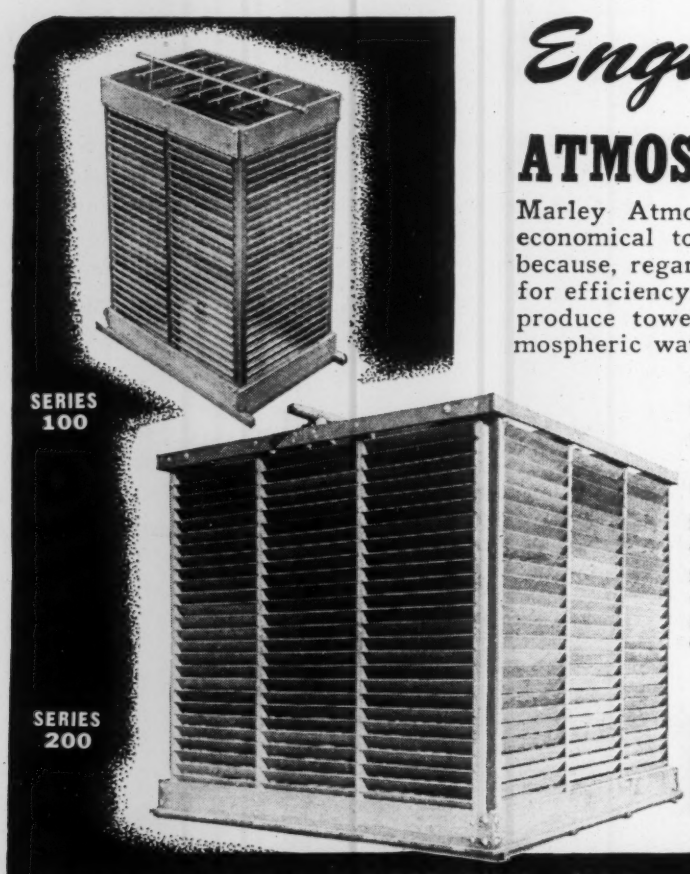
Thirty Sixth National Safety Congress and Exposition—sponsored by the National Safety Council, 20 N. Wacker Dr., Chicago 6, Ill. This event will be held October 18 to 22 and five hotels will house the safety sessions and expositions. The industrial safety exposition and industrial sessions will be held at the Stevens; industrial, school, and college sessions at the Morrison; and other industrial sessions at the Congress and La Salle hotels. The public safety exposition will be at the Sherman hotel.

Refrigeration Equipment Manufacturers Association and the Refrigeration Equipment Wholesalers Association—a joint meeting to be held October 21 to 23, French Lick, Ind. Talks and discussion periods on problems affecting both groups are scheduled for the morning of October 22 and the following morning will be given over to product section meetings. For additional information write REMA at 3751 Prospect Ave., Cleveland.

American Welding Society, 39 W. 39th St., New York City—annual meeting, October 24-29, Bellevue-Stratford hotel, Philadelphia.

Inert gas-shielded arc welding will be given considerable attention as two of the many technical sessions will be devoted to this subject. A paper on pipe welding, by John H. Zink, president, Heat & Power Corp., Baltimore, will be presented during the session on storage tanks, pressure vessels, and piping.

The concurrent National Metal Exposition will be held in the Commercial Museum and convention halls. The first educational lecture series will be given by Dr. R. D.



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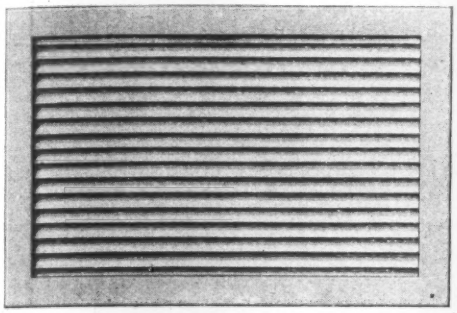

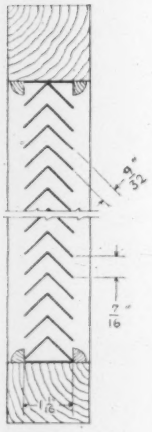

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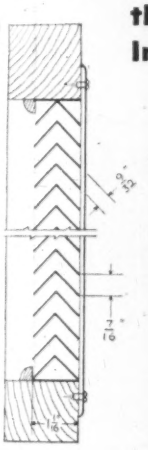

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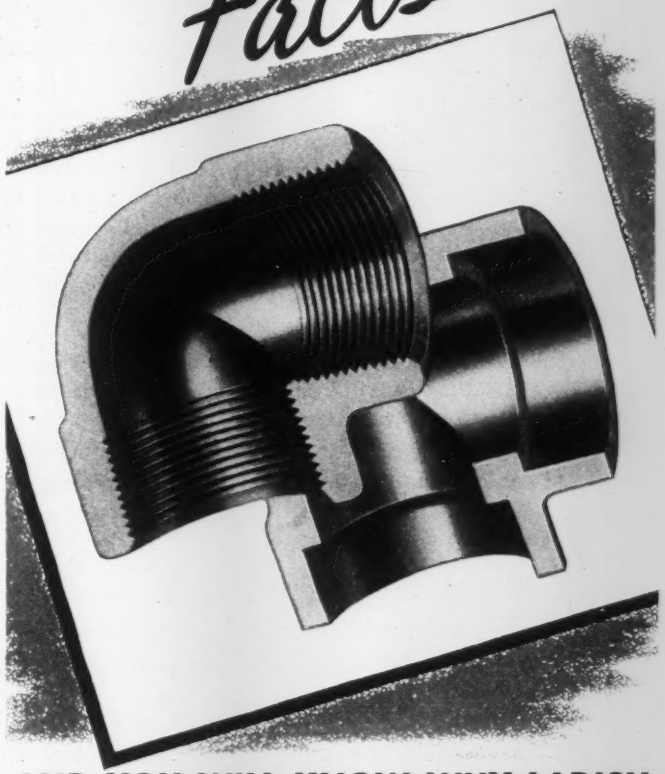

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Stout, department of metallurgy, Lehigh University. His three lectures will be on the metallurgy of arc welds in steel.

Third Annual Short Course in Instrumentation for the Process Industries—offered by the Agricultural and Mechanical College of Texas, October 26 to 28. The course will be conducted as a seminar with lectures and discussions on the subject of automatic control. Lectures will cover the measurement and control of temperature, pressure, liquid level, as well as time control and other allied subjects.

Anyone living either in or outside of Texas is eligible to take the course on payment of a $5.00 registration fee. Rooming accommodations and meals will be available on the campus and further information may be obtained from Prof. P. G. Murdoch, chemical engineering department, Texas A & M College, College Station, Tex.

American Society of Refrigerating Engineers, 40 W. 40th St., New York City—1948 annual meeting. December 5 to 8, Hotel Statler, Washington, D. C.

The technical program will be under the supervision of C. M. Ashley, chairman of the program committee, and W. S. Woodside will be the convention chairman.

Pan-American Engineering Congress, to be held late in 1948 or in 1949, South America—further information to be released by the Engineers Joint Council Committee on International Relations, 29 W. 39th St., New York City.

Ninth International Heating, Ventilating, and Air Conditioning Exposition, January 24 to 28, International Amphitheatre, Chicago—under the auspices of the American Society of Heating and Ventilating Engineers, 51 Madison Ave., New York City.

American Society of Heating and Ventilating Engineers, 51 Madison Ave., New York City—the 55th annual meeting, January 24 to 27, 1949, Stevens hotel, Chicago.

The Illinois Chapter will be host for the occasion and W. A. Kuechenberg is general chairman of arrangements.

Stoker Manufacturers Association, 307 N. Michigan Ave., Chicago—plans have tentatively been made to hold a one day membership conference in Chicago during the last week in January.

American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.—the following 1949 meetings have been scheduled:

Spring meeting and ASTM committee week, Edgewater Beach hotel, Chicago, February 28 to March 4.

Fifty second annual meeting, Chalfonte-Haddon Hall hotel, Atlantic City, June 27 to July 1.

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Weil Type R-hot and chilled water circulating

All ball-bearing pump. Requires only once-a-year lubrication. Capacities from 10 to 750 GPM. Two types—RU with packed Stuffing Box for Cooling Tower Service. RY with leakproof Mechanical Seal for hot or chilled water circulating. (see bulletin R5500)

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every part precision-built for long life. Every pump pre-tested before shipping.

COMPACT INSTALLATION

unit comes completely assembled. Requires little space.

Fig. 302

Check These Weil Pumps for Heating System Duty

Fig. R5506

Weil Type TR horizontal low and high pressure systems

Ball bearing, heavy duty—use standard motor at low speed—1750 RPM. Copper bearing steel receiver. Capacities to 100,000 sq. ft. E.D.R.; pressures to 125 P.S.I.

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Low return connections provide freedom of layout. Eliminates underground lines. Lines overhead may be used. Capacities of 500 to 10,000 sq. feet E.D.R. Has extremely low water line—cast iron receiver. (write for bulletin TVC-300.

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Model "400" furnished with tool tray, feet and all fittings (but without legs.)

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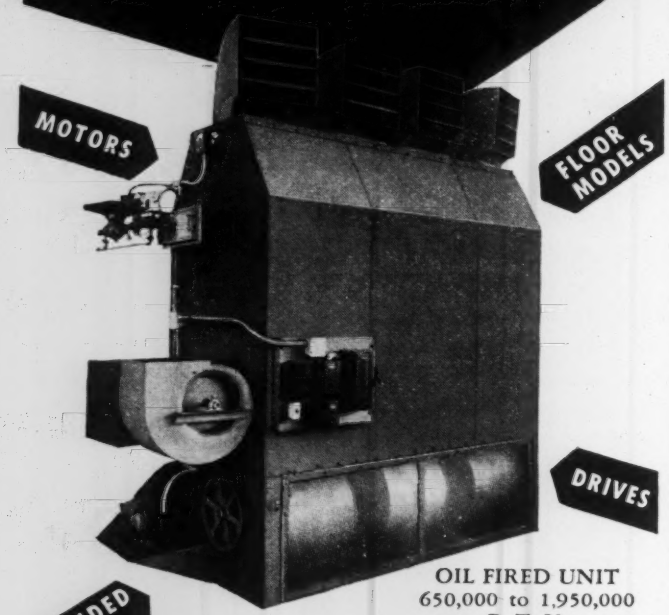

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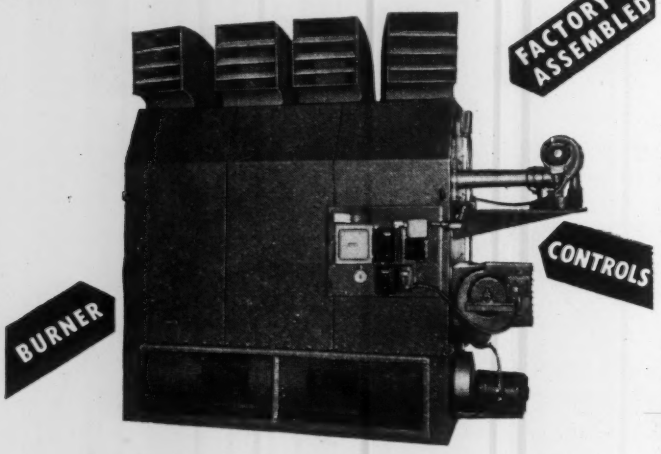

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Meetings & Conventions (Cont.)

First national meeting of the society on the west coast, Fairmont hotel, San Francisco, October 10 to 14.

American Foundrymen's Society, 222 W. Adams St., Chicago—1949 annual meeting, May 2 to 5, St. Louis, Mo.

Oil-Heat Institute of America, 6 E. 39th St., New York City—1949 national convention and industry exposition, the week of May 16, Boston. The convention committee has approved Mechanics Hall for the exposition and the Statler as the headquarters hotel.

American Society of Refrigerating Engineers, 40 W. 40th St., New York City—proposed 1949 Spring meeting, June 5 to 8. As tentatively planned, the technical sessions and committee meetings will be held aboard ship and will be combined with a cruise, from Montreal, on the St. Lawrence and Saguenay rivers. Stops for sightseeing will be made at Murray Bay, Tadoussac, and Quebec.

Sixth All-Industry Refrigeration and Air Conditioning Exposition, the week of November 14, 1949, Atlantic City—sponsored by the Refrigeration Equipment Manufacturers Association, 1107 Clark Bldg., Pittsburgh 22, Pa.

According to R. K. Hanson, show director, the general public is not invited and visitors must show credentials indicating they are members of the industry.

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Standard No. 20 $24.00 a pair
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These fully-patented **FLANGE-JACKS**, formerly manufactured by T. G. Persson Co., of Bloomfield, N. J., are job-tested and meet the requirements for fast, safe and easy gasket replacement.

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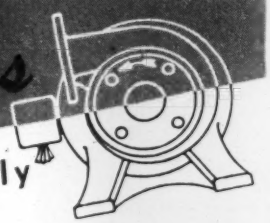

Operate efficiently in ANY position . . .

Weinman Unipumps are highly adaptable — they will operate efficiently regardless of the angle of installation on floor or wall. They require minimum space and are easy to install.

Unipumps are especially adaptable for circulation of chilled water or brine. Compactness, efficiency of operation and low maintenance cost, plus a wide range of modifications, make the Weinman Unipump outstanding.

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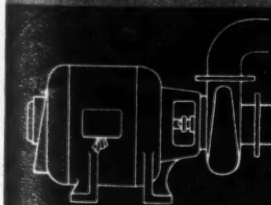

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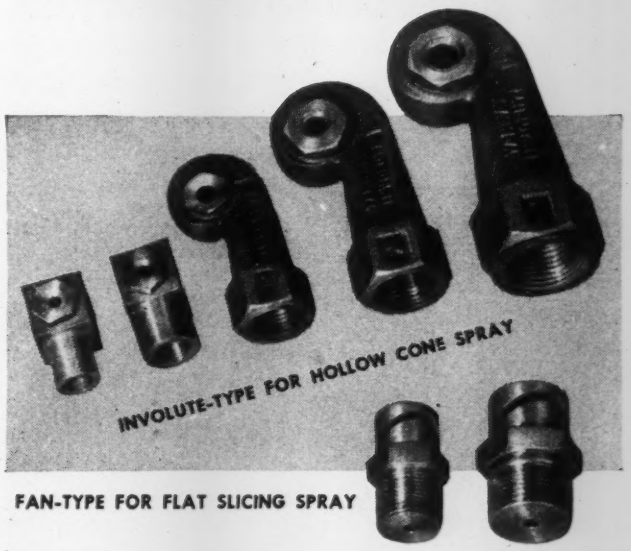

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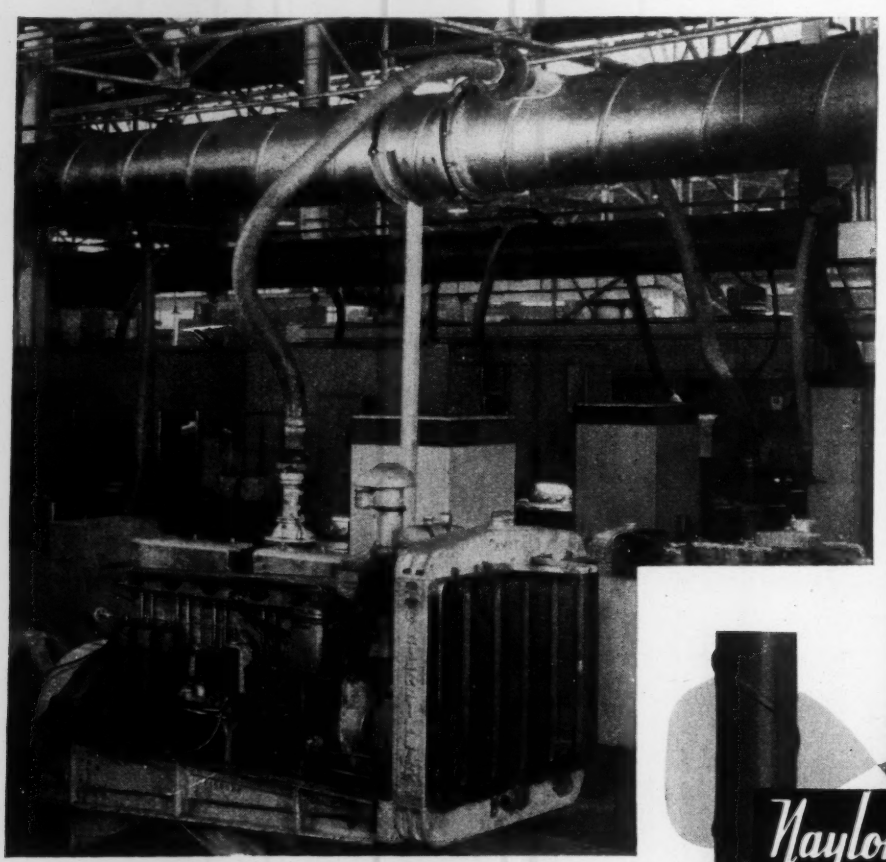
Ball and Roller Bearings

No. 6961—SKF Industries, Inc., Front St. & Erie Ave., Philadelphia 32, Pa., has issued an abridged edition of its general catalog on ball and roller bearings. While lacking the detailed technical data of the general catalog, the 76 page booklet devotes considerable space to load calculations, selection of shaft and housing tolerances, and conversion tables. A special section deals with the company's pillow blocks and includes data on mounting, lubrication, and maintenance.

Blowers, Fans, and Exhausters

No. 6962—A new edition of its bulletin, Lungs for Industry, has been released by General Blower Co., Morton Grove, Ill. Among the products which are described and illustrated are single and multi-stage turbo blowers, gas boosters, multi-blade exhausters of both the forward and backward curve type, steel plate exhausters, high temperature fans, welding fume exhausters, spray booth fans, propeller type exhaust fans, ventilating fans, rotary blowers, and roof ventilators.



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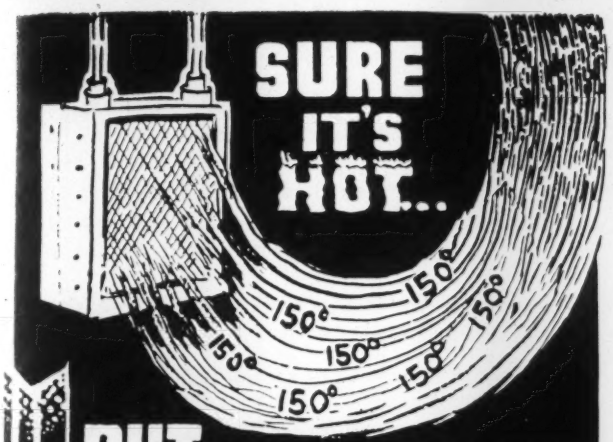

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Do you spend your heating dollars only to heat your ceiling? Or, do you want the very most from your heating dollar? If so, don't be confused by unit heaters offering great BTU delivery and high outlet temperatures. Any unit heater that fails to deliver warm air to the floor level where it is needed most is simply spending your heating dollars to heat that part of your building that does not require heating.

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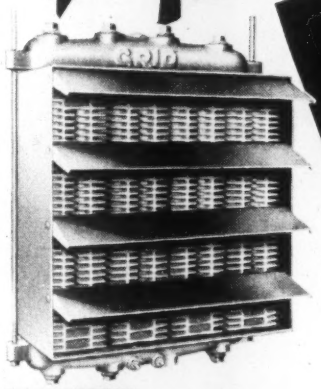

Investigate GRID Unit Heaters that are designed for low outlet temperature and greater air delivery. They are constructed to deliver warm air in greater volume to the working zone where it is needed . . . resulting in saving in fuel consumption, assuring the very ultimate from your heating dollar.

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● The NIAGARA "NO-FROST" METHOD assures uniform temperature without loss of capacity from frosting of refrigerating coils at any time.

By preventing frost accumulation, it not only does away entirely with the nuisance of defrosting. It sets a new and higher standard of refrigeration system performance...free from operating difficulty and maintenance trouble...and with lower costs, because you always get the full capacity of your compressor without the waste of power that comes from running with frost on the coils.

NIAGARA "NO-FROST" installations are operating successfully in every refrigeration application requiring temperatures below freezing...meat chilling and holding, pre-cooling and holding of fruits and vegetables, butter, egg and cheese storage, fish freezing, quick freezing of foods, ice cream hardening.

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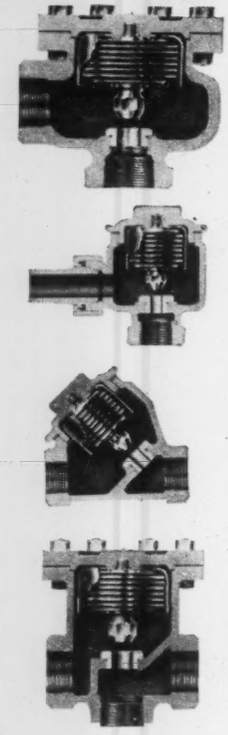

FASTER HEAT TRANSFER and LOWER FUEL COSTS are two of the immediate benefits of equipping each unit with its own trap. It's an ideal, efficiency-wise, that Nicholson is making possible in an increasing number of plants.

Nicholson steam traps make unit-trapping practical because: their low cost makes it economically possible; there is a Nicholson trap for every power, heat and process purpose; your Nicholson service engineer is experienced in planning a practical system.

Bulletin 1047 or see Sweet's

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Blower Type Unit Heaters

No. 6963—The line of "Recirculair" blower type unit heaters consists of 10 standard combinations utilizing two basic sizes for handling 1800 to 20,000 cfm. Bulletin 483, released by New York Blower Co., 32nd St. & Shields Ave., Chicago 16, Ill., includes information on various types of mountings, copper steam coils, and air filters.

Capacity Data for Concentric Orifices and Flow Nozzles

No. 6964—A simplified method for sizing orifices and flow nozzles in connection with orifice type meters is explained in a 10 page bulletin (T-100-M) issued by Hagan Corp., 323 Fourth Ave., Pittsburgh 19, Pa. For a given line size, meter differential and fluid quantity are determined by using a basic formula and a graph. The information obtained is said to be satisfactorily accurate, within certain limits, for the purpose. In addition to the data used in determining the orifice ratio, the bulletin contains a diagram covering recommended pressure tap spacing for flange, radius, and vena contracta taps, and another diagram showing the permanent pressure loss to be expected from installation of the primary device.

Combustion Test Set

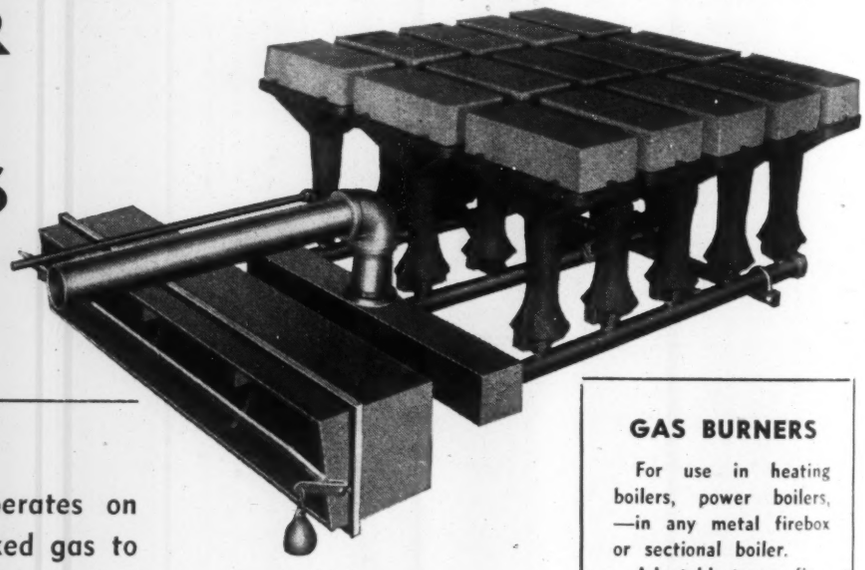
No. 6965—In calling attention to its line of combustion test sets, F. W. Dwyer Mfg. Co., 317 S. Western Ave., Chicago 12, Ill., has published a new bulletin (No. 220)

WEBSTER

Series F600

GAS BURNERS

50,000 to 10,000,000 Btu.



The Series F600 Burner operates on straight natural gas and mixed gas to 800 Btu. Gives perfect horizontal distribution. Fully automatic controls—that operate properly—can be easily applied.

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GAS BURNERS

For use in heating boilers, power boilers, —in any metal firebox or sectional boiler.

Adaptable to any firebox shape or size.

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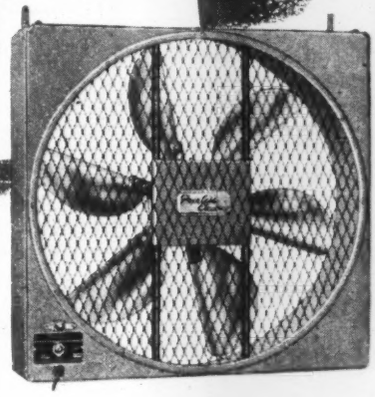
Stores
Homes



Peerless Electric

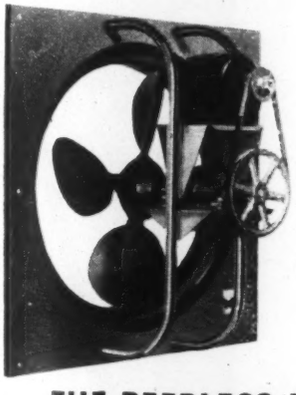
REVERSIBLE ALL-PURPOSE FAN

...A single, simple Peerless Electric plug-in PROFIT BOOSTER

UNIQUE in size and utility, this Peerless WF-30 All-Purpose, All-Metal Fan and Cabinet are 30″ square and only 5½″ deep . . . tremendous air capacity of 4220 C.F.M. high speed exhaust . . . low-cost operation . . . two speed ⅙ h.p. motor . . . reversible . . . exhausts day time heat or pulls in cool night air . . . thermally protected motor can't burn out.

Here's a real ready-to-plug-in appliance with dozens of commercial and domestic applications—a Peerless-quality fan that you can make a *volume* leader and a *profit* leader. Write for details TODAY!

...and a Peerless Electric easy-to-install VENTILATTIC FAN



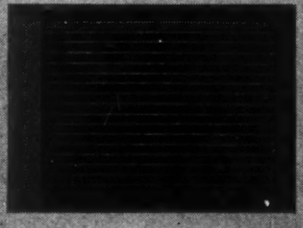
In every community there'll be big demand for this efficient "home cooler"—*blows heat out . . . pulls cool, fresh* air in. A boon for stores, theatres, dance halls and restaurants, too. This Peerless Ventilattic Fan (dependability proved by years of satisfactory service) can be mounted at attic window by using rubber feet supplied with the unit—then easily connected to window or opening in wall with canvas boot or duct. Five sizes 24″ to 42″ complete with motor. *WRITE for descriptive folder and prices.*

THE PEERLESS ELECTRIC COMPANY
Member Propeller Fan Manufacturers Association • Established 1893
WARREN, OHIO

Peerless Electric
MOTORS • FANS • BLOWERS

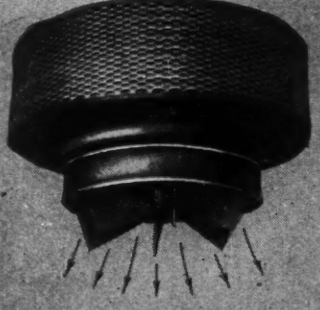
McCORD
HEATING AND AIR CONDITIONING PRODUCTS

BLAST HEATING COILS—AIR CONDITIONING COILS—ALL TYPES



All copper spiral fin tube construction with the tubes formed or bent permits uniform expansion without strain. Headers are heavy wall construction with tubes brazed into extended ferrules formed in the headers. Fins are helically wound and metallically bonded. May we send catalog?

VERTICAL TYPE UNIT HEATERS



A proven heating unit, modern in design, incorporating every unit heater advancement. McCord copper spiral fin tube construction creates air turbulence without undue restriction. Improved fan blades deliver large volume of air with minimum air noise. Guaranteed for 150 lbs. saturated steam pressure. Specify McCord.

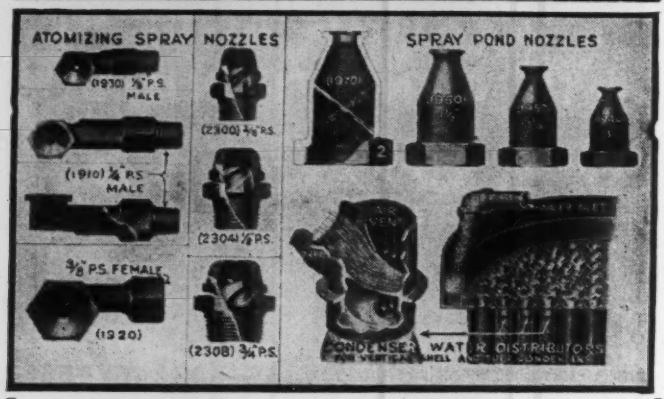
HORIZONTAL TYPE UNIT HEATERS

A time proven heating unit, modern streamlined in design, quiet, yet its rugged construction adapts it to all types of installations, guaranteed for use on No. 150 p.s.i. steam pressure. All copper heating element, individual spiral fin tubes free to expand without strain on joints. Standard motors with standard bases used. Wide range of capacities.

Save fuel with McCord Unit Heaters.

McCord CORPORATION
DETROIT 11, MICH.

QUALITY always wins!
MARTOCELLO Products are fully DEPENDABLE



ATOMIZING SPRAY NOZZLES, SPRAY POND NOZZLES, and CONDENSER WATER DISTRIBUTORS

For Vertical Shell and Tube Ammonia Condensers

ALL MARTOCELLO SPRAY NOZZLES are manufactured with precision and of a design which has been thoroughly tested for maximum results and durability. They are guaranteed to give satisfaction. Successful, efficient results depend largely upon selecting the proper number, type and size of Nozzles suitable for your installation.

THE MARTOCELLO CONDENSER WATER DISTRIBUTORS are now used as standard equipment by Progressive Refrigerating Engineers in solving their Manpower problem, because they require no attention and assure users of the lowest Condenser Operating Pressures and Minimum Power Cost. It will pay you to consult us. WRITE or WIRE for further information.

Jos. A. Martocello & Co. 229-231 NORTH 13th STREET PHILADELPHIA 7, PA

"Serving the Ice Industry Since 1916" "There is no Substitute for MARTOCELLO QUALITY"

which depicts in detail the various components of the sets and tells how each is used. Basically the sets include a CO_2 indicator, a small draft gage, and a pencil type stack thermometer. Various types of instrument combinations are covered, and the company's new smoke gage is described.

Condensation Pump and Receiver

No. 6966—The type No. UV condensation pump and receiver unit, offered by Skidmore Corp., St. Joseph, Mich., is described and illustrated in Bulletin No. 19-A. The unit, designed for use where returns are too low to permit the use of horizontal type pumps, is available in a variety of sizes from 3 to 60 gpm. Capacities, discharge pressures, dimensions, and other data are tabulated.

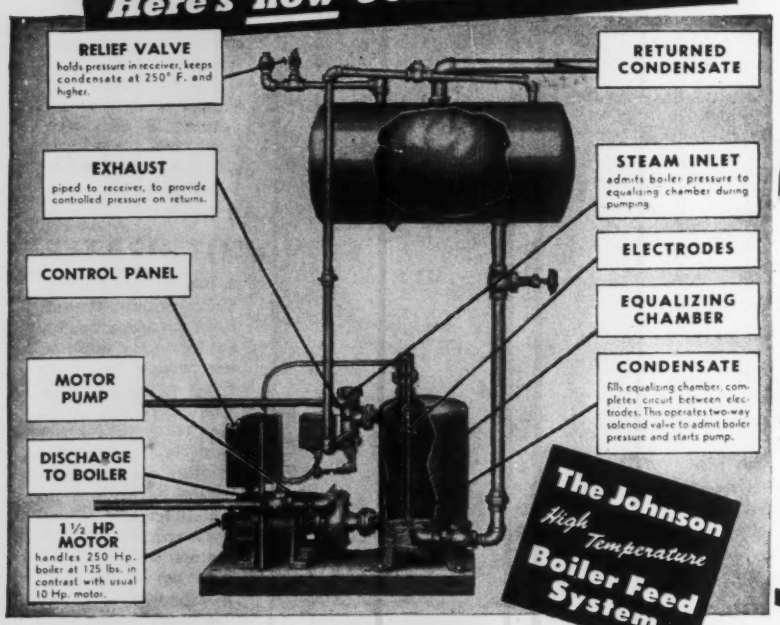
Evaporative Condenser

No. 6967—Features, dimensions, construction data, and other pertinent information on the evaporative condenser offered by R. E. Ristow, 2228 S. Atlantic Blvd., Los Angeles 22, Calif., are covered in a new four page bulletin. The "Risto" unit is available in a variety of sizes for handling air quantities from 1500 to 37,000 cfm.

Evaporative Coolers

No. 6968—Bulletin C-1100-B27A, released by Worthington Pump and Machinery Corp., Harrison, N. J., describes the WCZ series of evaporative coolers which are particularly recommended for cooling diesel engine jacket

Here's how Johnson does it –


RELIEF VALVE
holds pressure in receiver, keeps condensate at 250° F. and higher.
RETURNED CONDENSATE
EXHAUST
piped to receiver, to provide controlled pressure on returns.
STEAM INLET
admits boiler pressure to equalizing chamber during pumping
ELECTRODES
CONTROL PANEL
EQUALIZING CHAMBER
CONDENSATE
fills equalizing chamber, completes circuit between electrodes. This operates two-way solenoid valve to admit boiler pressure and starts pump.
MOTOR PUMP
DISCHARGE TO BOILER
1½ HP. MOTOR
handles 250 Hp. boiler at 125 lbs. in contrast with usual 10 Hp. motor.

The Johnson High Temperature Boiler Feed System

..pays its way in one year

Admittedly the claims made for this Johnson System sound like a pretty big order. But there are hundreds of installations and plenty of sound engineering reasons, as pointed out opposite, to back them up. The Johnson System accomplishes two big things—gets condensate back to boiler at higher temperatures, and eliminates the power-consuming task of pumping against boiler pressure. In dollars and cents this amounts to power savings of as much as 60%, fuel savings up to 15%.

Available in sizes for boilers from 30 to 500 Hp., up to 200 lbs. pressure. Multiple units for larger boilers.

Write for literature and the name of your nearby Johnson representative.

Product of The Johnson Corporation

806 WOOD STREET, THREE RIVERS, MICHIGAN

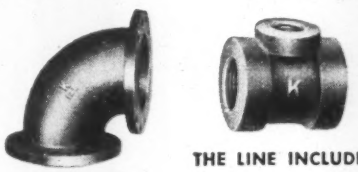
UNIVERSITY OF MICHIGAN LIBRARIES

I WONDER WHO'S KISSING HER NOW

You'll make your customers happy by supplying them with "K" fittings. The threads are straight, full, and perfect. They take hold easily because the chamfer in the opening guides the pipe thread in.

Yep! It's a pleasure to work with "K" fittings . . . a satisfaction, too, to be sure there won't be any leaks from bad joints or sand holes or cold checks.

"K" fittings are precision-cast, precision-machined, precision-inspected. Get 'em from your supplier.



THE LINE INCLUDES:

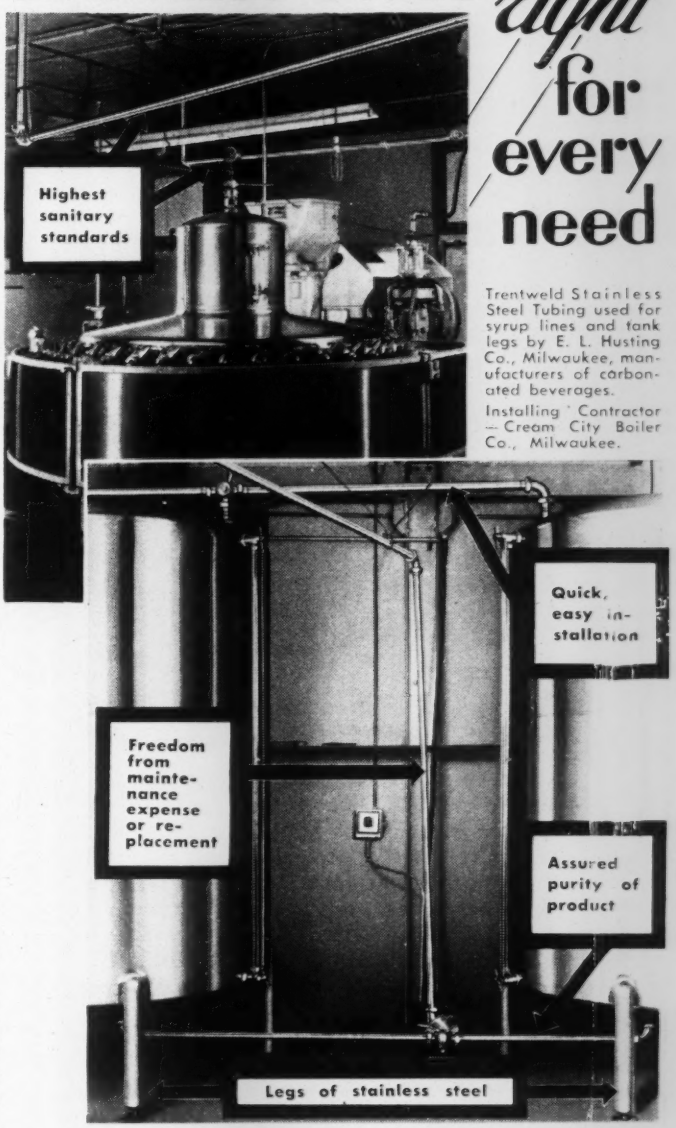
- Standard and Extra Heavy Cast-Iron Screwed Fittings
- Standard and Extra Heavy Companion Flanges
- Standard Flanged Cast Fittings
- Drainage Fittings

K PRECISION FITTINGS

KUHNS BROTHERS CO.
DAYTON 1, OHIO

COMBINED SALES FACILITIES at Malleable Iron Fittings Company, Branford, Conn., and Kuhns Bros. Co., Dayton, Ohio.

Flow lines of Trentweld STAINLESS STEEL right for every need


Highest sanitary standards
Quick, easy installation
Freedom from maintenance expense or replacement
Assured purity of product
Legs of stainless steel

Trentweld Stainless Steel Tubing used for syrup lines and tank legs by E. L. Husting Co., Milwaukee, manufacturers of carbonated beverages. Installing Contractor — Cream City Boiler Co., Milwaukee.

WHEREVER flow lines must carry corrosive substances in any form, the efficiency of Trentweld stainless steel tubing is all inclusive. Highly resistant to the action of acids or alkalines, this rugged thin-walled tubing is made to deliver substantial savings over the years to the installation owners in eliminating replacement costs and maintenance expense. Of interest, too, initially, is the fact that this light weight tubing, in diameters up to 30", is easy to handle under any condition. It saves manpower, makes installation work a smooth-running, time-saving job. Trent engineers are at your call at all times to give you whatever help or information you may require. Without obligation, write:

TRENTWELD STAINLESS STEEL TUBES

District Offices—New York, Chicago

TRENT TUBE MFG. CO.

430 Church St. East Troy, Wisconsin

UNIVERSITY OF MICHIGAN LIBRARIES

How to Give Bad Air the *BIG PUSH*

Swartwout Ject-O-Valve forces heat and fumes through your roof

. . . keeps workrooms "workable"

Wherever you have a situation that calls for a *big breeze* to get rid of heat, fumes, vapor or dust, Ject-O-Valve is the Roof Ventilator for the job. A scientifically shaped propeller fan, driven by an electric motor that costs little to run, opens the ventilator doors and literally *throws* your heavy load of bad air out and up to where the breezes carry it away. The top is open only when fan is running; the powerful air-stream keeps out all weather.

Well-proportioned, sturdily built, Ject-O-Valve is made in 5 sizes, 28 different capacities. There's one to fit *your need!* Mounts on any type of roof. Hinged top for easy servicing.

Overcome employee "griping" about fumes and heat. Install Ject-O-Valve to push bad air out of your plant. Write today for more information.

THE SWARTWOUT CO., 18568 Euclid Avenue, Cleveland 12, Ohio

Swartwout *Controlled* **Air Circulation**

EQUIPMENT FOR EFFECTIVE ECONOMICAL VENTILATION OF INDUSTRIAL BUILDINGS

water. Available with coil depths of 16, 20, or 24 rows, they are designed for both inside and outside use. Five sizes are offered with capacities ranging from 5500 to 73,000 Btu per min and with air quantities from 2000 to 12,000 cfm. The eight page bulletin covers design and construction features, dimensions, and specifications.

Fittings and Flanges of Stainless Steel

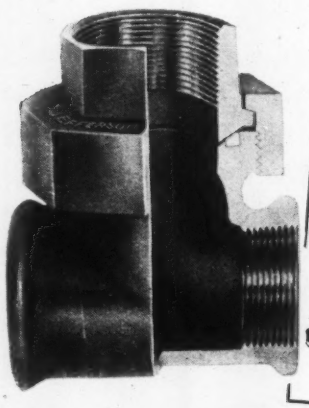
No. 6969—Available in stainless steel types 304, 347, 316, and other materials, fittings and flanges of Taylor Forge & Pipe Works, P.O. Box 485, Chicago 90, Ill., are described and illustrated in Bulletin 483. Dimensions and prices of new type fittings and flanges are included.

Flexible Couplings

No. 6970—Catalog No. 48 has recently been issued by Ajax Flexible Coupling Co., Inc., Westfield, N. Y. It covers the company's standard types S and A, as well as shear pin, brake drum, bolt-on, and detachable hub couplings. Information on forged steel and cast semi-steel construction is given, and capacity and dimension data are included.

Flush Type Air Diffuser

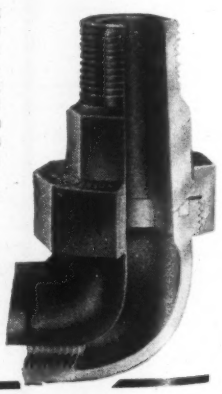
No. 6971—The "Agitair" RTC air diffuser (square or rectangular) is especially designed for use in acoustical ceilings and is made in modular sizes to conform to standard tile dimensions. A new six page bulletin issued by Air Devices, Inc., Dept. RTC, 17 E. 42nd St.,



IMPORTANT SAVINGS ON PIPING MAINTENANCE WITH JEFFERSON

SPECIALTY UNIONS

There's no reason to spend good money on piping maintenance . . . Simply make a good job from the start by installing Jefferson Specialty Unions. They're time-tested and reliable, have the exclusive brass seating feature to assure a tight, lasting joint. Jefferson fittings may be broken time and again without lessening their efficiency, and you can't dislodge the brass seat by screwing pipe ends in too far . . . no maintenance troubles . . . no shutdowns. Investigate this superior line now. Just drop us a postcard for more detailed information.



JEFFERSON UNION CO.

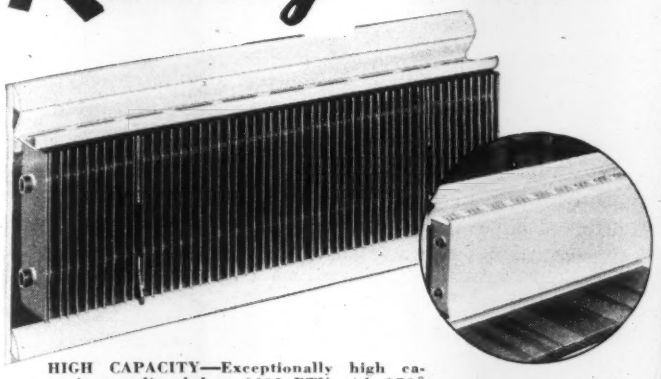
607 West 26th Street, New York 1, N. Y.

35 Fletcher Avenue, Lexington 73, Mass.

65 Gooding Street, Lockport, N. Y.

Designed for Better Living . . .

Rittling BASEBOARD HEATING

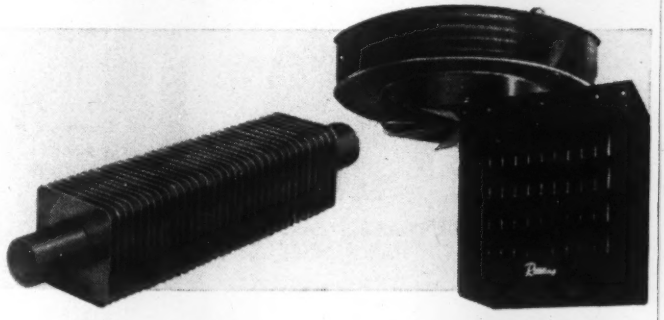


HIGH CAPACITY—Exceptionally high capacity per lineal foot (600 BTU with 170° water) permits operation most of the time on low water temperature; thus effecting fuel economy, draftless distribution and increased wall cleanliness.

SIMPLE INSTALLATION—(Does not have to be recessed.) Requires only a few wall brackets and fittings.

DURABLE CONSTRUCTION—Heavy wall copper tubing, aluminum radiating fins and heavy gauge sheet steel grilled covers.

Immediate Delivery *Write for Catalog B1*



MAGNA Fin CONVECTORS
Write for Catalog MFC

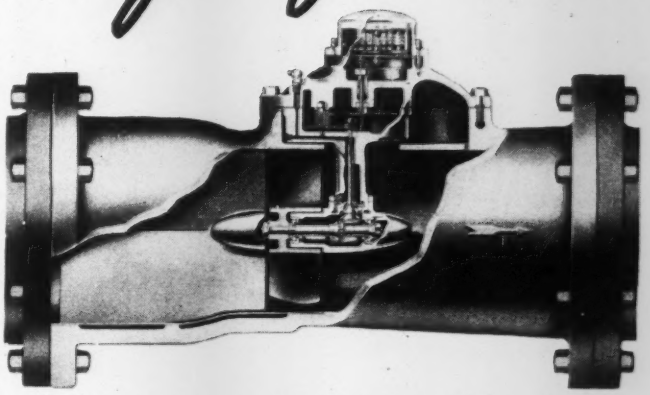
MAGNA Therm UNIT HEATERS
Write for Catalog MTH

THE Rittling CORP.

Manufacturers of Fin Tube Surfaces. Inquiries Invited.

1292 NIAGARA ST. BUFFALO 13, N. Y.

Propeloflo METER

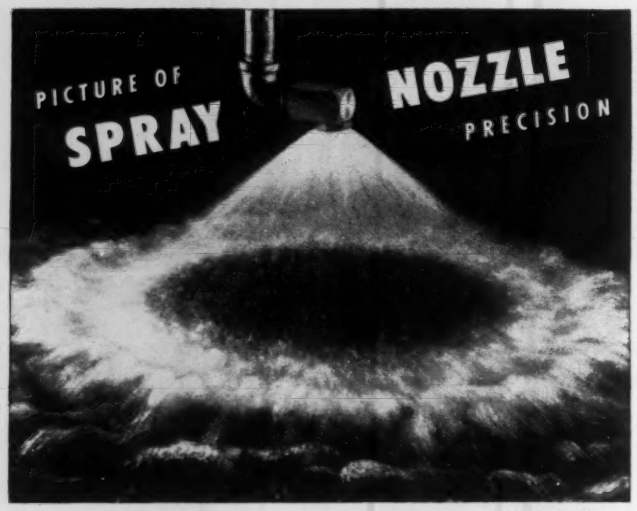


BUILDERS Propeloflo Meter takes the guesswork out of main line metering — keeps accurate count of WHERE water is going AND HOW MUCH. Widely accepted for its proven dependability, this Meter gives gallon-by-gallon information on actual flow conditions. The unit is totally self-contained and self-actuated; reads directly in gallons. It's easy to install, too — as easy as adding a new pipe section. BUILDERS streamline Venturi design gives accuracy within ±2% over a wide range and its low pressure loss minimizes pumping costs. For Bulletin 350A, address Builders-Providence, Inc., (Division of Builders Iron Foundry), 41 Codding Street, Providence 1, R. I.

BUILDERS PRODUCTS

Venturi, Propeloflo and Orifice Meters • Type M, Flo-Watch and Flo-Gage Instruments • Shuntflo Steam Meters • Kennison Nozzles • Chronoflo Telemeters • Conveyoflo Meters

BUILDERS PROVIDENCE
Instruments



Specialized engineering and precision construction have only one purpose here . . . to give you exact control of spray pattern, distribution, and atomization . . . as well as impact where required, for any given liquid volume and pressure. For your requirements, you will find that Spraying Systems Spray Nozzles can always give you more in performance . . . to improve operations and lower cost. Catalog 22 gives you all the facts.

SPRAYING SYSTEMS CO.

Engineers and Manufacturers

4033 W. LAKE STREET • CHICAGO 24, ILLINOIS

WRITE FOR CATALOG 22

New York 17, N. Y., shows how the diffuser is installed with various types of suspended ceiling construction. Sizes, patterns, and typical installations are also shown.

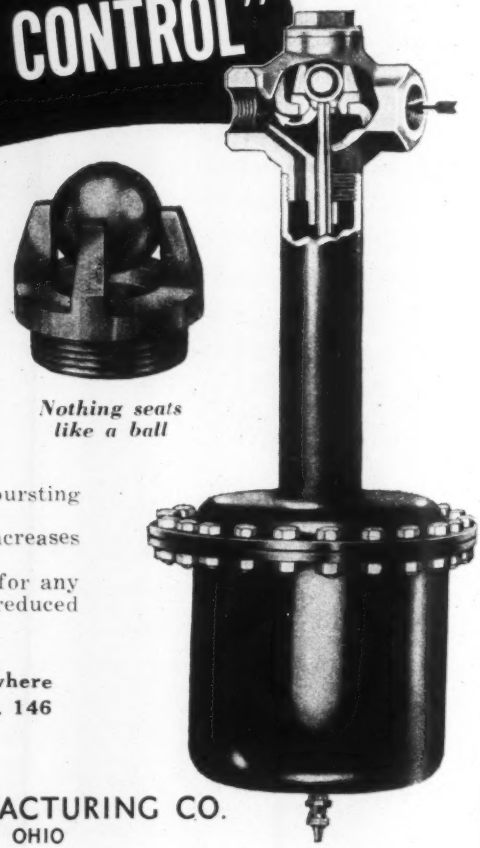
Gages for Liquid Level Application

No. 6972—Swift Lubricator Co., Inc., Elmira, N. Y., manufactures a line of gages for liquid level applications such as tanks, boilers, traps, separators, receivers, condensers, filters, and other similar products. Standard gages are packed for steam and water service, but packings for petroleum and other products are available. Gage glasses are supplied in clear or red line with guard rods to match, for any center mounting distances. The company has recently prepared a complete set of specification prints drawn to scale. In addition to showing overall dimensions, the drawings include simple formulas for determining glass and guard rod lengths.

Gas Scrubbers and Coolers

No. 6973—Bulletin No. H-203, issued by Peabody Engineering Corp., 580 Fifth Ave., New York 19, N. Y., covers the company's line of gas scrubbers and coolers. Units are designed to clean gases for any purpose, to cool gases used in processing, and to absorb soluble components. They are available in sizes from 50 to 100,000 cfm and may be designed for pressure, vacuum, or atmospheric service. Materials of construction include mild steel, stainless steel, other alloys, and cast iron, depending on the application.

"KEEP YOUR PRESSURE UNDER CONTROL"



Nothing seats like a ball

Klipfel No. 431 air-loaded, ball type reducing valve offers these advanced features for dependable, closer regulation . . . greater capacity and durability.

Ball inner valve and seat of hardened, stainless steel are self-aligning . . . tight seating . . . streamlined. Non-sticking valve is accessible and durable.

Air loading in drawn steel dome varies from vacuum to 150 P.S.I. for corresponding reduced pressure. Constant loading pressure from closed to full open for constant reduced pressure.

Clear neoprene diaphragm balances between equal pressures . . . no bursting pressure . . . no fabric—therefore long-lived.

Pitot tube in valve body helps maintain full reduced pressure as demand increases . . . no external control pipe needed.

No stuffing box . . . no friction . . . therefore sensitive control. Suitable for any ordinary fluid below 250 P.S.I. initial pressure, vacuum to 150 P.S.I. reduced pressure.

Klipfel

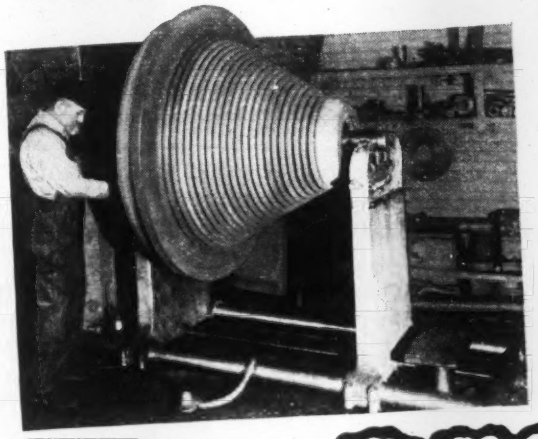
AUTOMATIC REGULATING VALVES

Sold through wholesalers everywhere
Write Dept. C-9 for Bulletin No. 146

KLIPFEL MANUFACTURING CO.
HAMILTON, OHIO

CASE REPORT No. 49 from a series of actual cases recording the successful application of BEAR DY-NAMIC BALANCING to Industry.

BEAR BALANCER "TAMES" 1800-POUNDER



For over four years, Centrifugal & Mechanical Industries Inc., of St. Louis, Mo., has successfully Bear-Balanced various centrifugal parts weighing from 25 to 1800 lbs. Balance is attained by metal-removal, drilling or welding

When this rotating basket for a 48" Continuous "C-M-I" Centrifugal Dryer was first rotated on the Bear Balancer, it whirred and whined with all the fury of a Dy-Namically un-balanced body. Within minutes, the Bear-Balancing operator "tamed" these 1800 lbs. of whirling metal into a smooth-performing, quiet Dy-Namically Balanced object.

This "act was performed" in the shop of Centrifugal & Mechanical Industries and it is being repeated a hundred-fold by manufacturers in many different lines, with rotating parts such as the following, weighing from 4 oz. to 8 tons!

Airplane wheels
Armatures
Blowers
Centrifugal dryers
Clutches
Clutch plates
Crankshafts
Dampdrying baskets
Damper wheels
Drying machine screens
Extractor baskets
Fans
Fan-Armature assemblies
Flywheels
Gears
Hammermill rotors
Heat treating blowers
Heat treating fans
Impellers
Propellers
Pulleys
Rotating baskets
Rotors
Sheaves
Vari-speed pulleys
Washing machine parts
Wood cutters

Operations similar to yours are most likely well represented in our file of successful users of Bear Dy-Namic Balancing. Write for complete data, as well as a copy of the latest Bear Industrial Balancing Catalog. Bear Mfg. Co., Dept. H-16, Rock Island, Ill.

BEAR

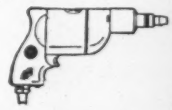
STATIC AND *DY-NAMIC BALANCING* MACHINES

2727

Here's Your "Handful of Power" for Continuous Drilling

A Black & Decker Electric "HOLGUN"* is an easy drill to handle, weighs only three pounds, measures only 6¾" overall. Yet, this compact tool has abundant power for continuous drilling that saves time in all kinds of heating, piping and air conditioning jobs.

Drives twist drills up to ¼" . . . wood augers up to ½" . . . small wire brushes for cleaning and burnishing . . . B & D Hole Saws for cutting clean, round holes up to 1⅛" diameter in any material a hacksaw will cut. Ideal for working in hard-to-reach places. Requires less muscle to operate. Smooth housings, with famous "Pistol Grip and Trigger Switch," fit naturally into either hand.



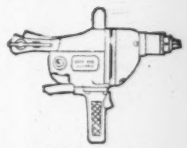
Black & Decker Electric "SCRUGUNS"* are perfect team-mates for these drills to speed up many sheet metal assembly operations. Shaped just like the HOLGUN. Insure greater accuracy and uniformity with minimum operator fatigue. For full information on HOLGUNS, SCRUGUNS and many other Portable Electric Tools, see your nearby Black & Decker Distributor. Write for free catalog to: The Black & Decker Mfg. Co., 628 Pennsylvania Ave., Towson 4, Maryland.

* Trade Mark Reg. U. S. Pat. Off.

LEADING DISTRIBUTORS EVERYWHERE SELL

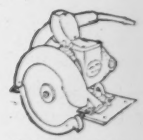
Black & Decker

PORTABLE ELECTRIC TOOLS



ELECTRIC DRILLS

ELECTRIC SANDERS



ELECTRIC SAWS

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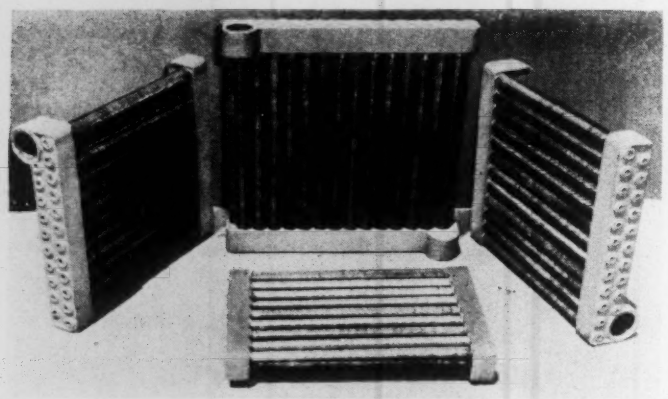


GUARANTEED HEATING COILS

Efficient and stable at steam pressures up to 200 lbs. All expansion stresses are taken up in the heating section itself. No brazing or welding in assembly. Encased coils standard equipment ready for installation in any position or stacking arrangement.

Widths 8¾" to 34". Tube lengths up to 120". Coils furnished with or without casing.

Copper Tubes and Fin with Cast Iron Headers. All coils inspected for workmanship and tested hydrostatically at minimum of 300 PSI. Tube within a tube to prevent freezing when required. Fins 6 - 7 - and 8 per inch.

IMMEDIATE DELIVERY—*Write for Bulletin 147*

CHICAGO FAN & FIN COIL CO.

1937 W. Walnut St., Dept. A **Chicago 12, Ill.**

Heating and Drainage System for Steam Heated Equipment

No. 6974—The "Quick-Temp" heating and drainage system for steam heated equipment is designed to provide continuous steam circulation and air removal. It is available from Fred H. Schaub Engineering Co., Inc., 2110 S. Marshall Blvd., Chicago 23, Ill., and is described and illustrated in Bulletin No. 548.

Industrial Fan With Manganese Bronze Wheel

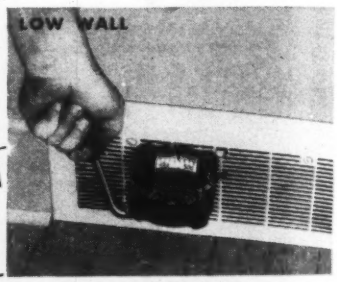
No. 6975—A recent four page bulletin, published by New York Blower Co., 32nd St. & Shields Ave., Chicago 16, Ill., gives data on the No. 10 G.I. fan. This unit has a 10 in. managanese bronze, paddle type wheel and is said to be sparkproof, acid resistant, and suitable for temperatures up to 350 F. It is designed to handle from 230 to 920 cfm and to operate at pressures up to 9 in. water.

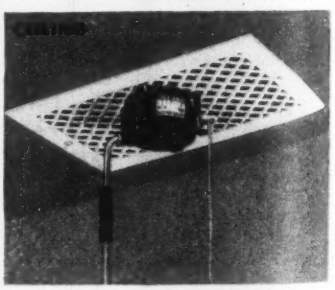
Integration of Industrial, Commercial Firms Serving the Oil and Gas Industries

No. 6976—A 48 page, pocket sized booklet issued by Dresser Industries, Inc., 1130 Terminal Tower, Cleveland 13, Ohio, lists its 13 operating companies and identifies the products and services of each. Entitled, Who We Are and What We Make, the booklet illustrates equipment at work in the oil, gas, chemical, mining, and other industrial fields. Also included are a number of pages showing gas fired heating equipment for commercial and industrial use.

AIRITE Direct-Reading AIR VELOCITY METER

RANGE—0-1000 FT./MIN.
20 FT./MIN. SCALE DIVISIONS





8" SCALE—Widest Scale of Any Mechanical Air Velocity Meter Ever Designed!

The AIRITE is an unsurpassed sales and service aid in heating, ventilating and air conditioning work. On installation and service work it is used to determine velocity and direction of air flow from registers and grilles for the purpose of checking rate of air delivery, balancing the system and adjusting deflecting vanes and louvers of registers so as to obtain "draft free" air distribution. These tests cut installation and service time, prevent expensive call-backs, and promote customer goodwill. The AIRITE is equally helpful for selling new equipment or modernization. It can be used in many ways to convincingly demonstrate discomforts and inefficiencies of a worn-out or inadequate system.

The AIRITE is entirely self-contained. It has no hose or probe, and gives all readings required for heating, ventilating and air conditioning work. The detachable handle facilitates use of the AIRITE at low wall or high side wall registers. By screwing a ⅛" pipe into the handle the AIRITE can be conveniently held against ceiling grille.

The AIRITE is equipped with a unique scale lock which makes it possible to retain the reading until the lock is released. For ceiling grille readings, this lock is easily manipulated by means of a piece of string. This feature makes the AIRITE exceptionally adaptable for indicating air velocity in hard-to-reach or dimly lit locations.

Dealer's Net Price *with leatherette carrying case* . . . **$19.80**

Ask your jobber for the AIRITE or write for Leaflet 749.

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Plan HEAT TRANSFER with REMPE

Our Long Experience at Your Service

HEAT TRANSFER EQUIPMENT
REMPE CO.
Founded 1890

ENGINEERED and BUILT for EFFICIENT DEPENDABLE PERFORMANCE

The Rempe "HOT SPOT" Fuel Oil Preheater

This efficient heater is available in 16″ or 14″ diameter size, and for use with hot water or steam. For use in oil storage tanks up to 12 feet diameter.
List Price $87.50

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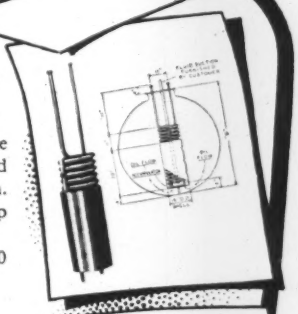
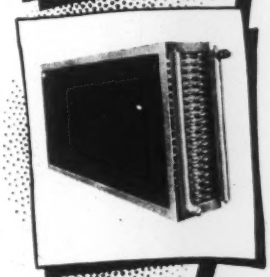


Rempe Fin Coils for Heating or Cooling Application

Fin Coils designed by Rempe always carry their heat load with ease because they are never overrated. Made for any refrigerant, cold water, hot water or steam. For any temperature between minus 60° to plus 350° F.

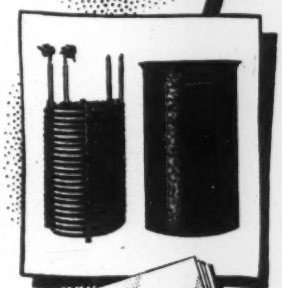
Send us your special problems.



Rempe Pipe Coils for all Process Work

Rempe has been making pipe coils for 57 years. Any diameter or any length, to your specifications or our design. Can be supplied in any Steel, Alloy, Stainless Steel, Copper or Aluminum.

Send full details for engineering assistance or quotation.



The Rempe Engineering Data Book

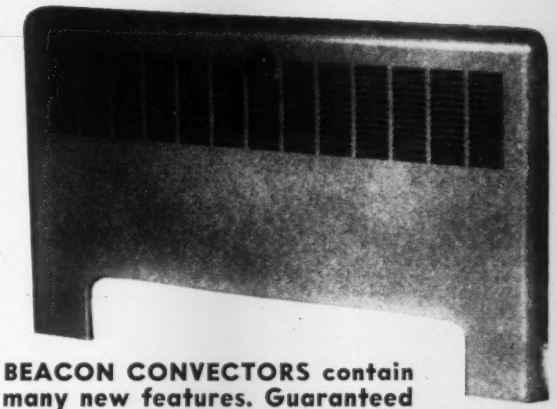
Most essential to the Engineers Library. A request on your letterhead will bring this Complete Engineering Data Book for design of Pipe Coils or Fin Coils.

REMPE COMPANY

342 N. SACRAMENTO BLVD. • CHICAGO 12, ILLINOIS

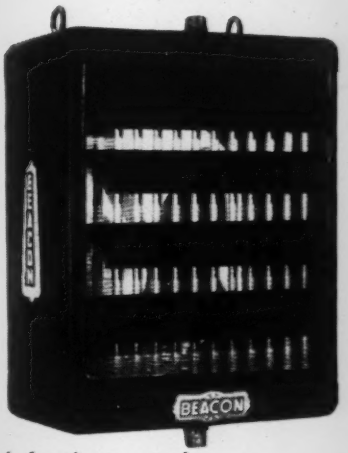
BEACON

CONVECTOR RADIATION



BEACON CONVECTORS contain many new features. Guaranteed leakproof because every unit is tested, by both hot water and air, under 150 lbs. pressure. Tubes are silver-brazed on the bronze header forming a complete rust-proof unit. New built-in damper allows complete closing of grille, quickly shutting off heat.

UNIT HEATERS



BEACON UNIT HEATERS possess all the features necessary for highly efficient, trouble-free performance. Fundamentally correct in both design and construction.

- Expansion cracks prevented by free-floating elements in casing.
- All parts coming in contact with steam made of copper.
- Cabinets made of heavy gauge welded furniture steel.
- Resilient base standard motors used.
- Adaptable to all types of construction.
- Wide range of capacities.

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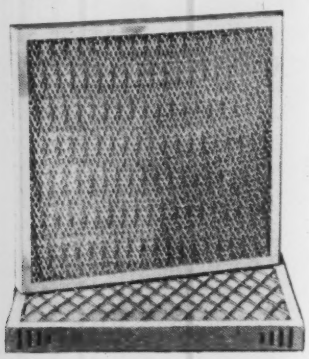
For Air Conditioning, Heating and Ventilating



Greater efficiency—lower resistance is yours with an AIRCOR Air Filter.

A permanent, cleanable viscous type filter of all galvanized construction, having full bronze welded corners. Expanded metal face plate acts as lint arrestor to provide easier cleaning and servicing. Rated filtering efficiency 98.5%. In standard 1" and 2" thickness.

Also available for heavy duty service on industrial and special applications—in 2" to 4" thickness. Holding frames (for V-type or straight banks) are made for all type filters.

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Air Filter Corporation

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Aircor

Liquid Level Recorders

No. 6977—Construction details and typical installations of the "Hi-Lo-Graph" remote liquid level recorders are featured in Bulletin WG-1830. The manufacturer, Yarnall-Waring Co., Mermaid Lane, Philadelphia, Pa., states that this new recorder utilizes a vibrating frictionless pen arm operating on a 24 hr rotating chart. The active section of the chart is illuminated from the back so that the pen is also visible as an indicating pointer. The recorders are offered for use with boilers, heaters, storage tanks, and other vessels in power and industrial process plants.

Low Temperature Welding

No. 6978—The Vol. 5, No. 3 issue of the house organ published by Eutectic Welding Alloys Corp., 40 Worth St., New York 13, N. Y., is largely devoted to explaining how 15 of the most popular welding alloys offered by the company are used in production and repair work and how the process of "low heat welding" is used to advantage. Also featured is the company's "Cuttrode" cutting electrode.

Machine Molded Cast Iron Pulleys

No. 6979—Machine molded, cast iron pulleys are the subject of Catalog No. 60, issued by Pyott Foundry & Machine Co., 328 N. Sangamon St., Chicago 7, Ill. Pulleys covered include solid rim and hub, solid rim and split

WATER SCALE ?

BY THE SKILLFUL USE OF CHEMICALS ALONE WE CAN CLEAN YOUR WATER-COOLED AIR CONDITIONING EQUIPMENT SCIENTIFICALLY AND SAFELY.

WE RESTORE TO ORIGINAL OPERATING EFFICIENCY THE ENTIRE INTERIORS OF CONDENSERS, HEAT EXCHANGERS, PRE AND AFTER COOLERS, JACKETS, PIPE LINES, TURBINES AND OTHER EQUIPMENT.

WHY ALLOW SCALE OR ALGAE SLIME TO PROGRESSIVELY LOWER THE EFFICIENCY OF YOUR PLANT?

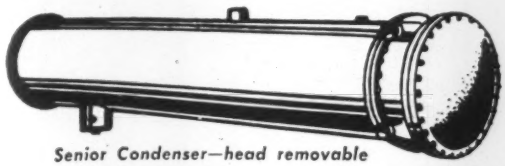
A SMALL CREW OF OUR MEN CAN ACCOMPLISH AMAZING RESULTS IN A FEW DAYS AND LEAVE YOUR PLANT IN "LIKE NEW" CONDITION.

WRITE TODAY FOR OUR LITERATURE OR CONSULTATION—NO OBLIGATION.

APEX ENGINEERING COMPANY

CEN. 2909 — 75 E. WACKER DRIVE — CHICAGO 1, ILL.

CONTINUOUSLY SERVING THE REFRIGERATION INDUSTRY SINCE 1919



Senior Condenser—head removable without breaking water connections

Standard—in and out water connections at same end

Freon Condensers

SHELL AND TUBE TO 460-TON CAPACITIES

Acme Freon Condensers, with "all-in-one" tubing, are constructed to give maximum heat transfer in a minimum space. Removable, replaceable, and easily cleaned heads and tubing, with heavy seamless steel shells, mean durability and accessibility. Specify Acme Condensers on your next job—there's a size and type for every commercial refrigeration need.

ACME PRODUCTS ★★★

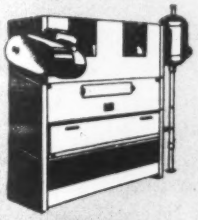
It is easy to select from the Acme Catalog 23-B. Write for yours today.

ACME INDUSTRIES, INC.

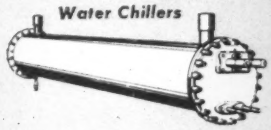
Jackson, Michigan

Representatives in Principal Cities

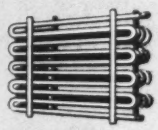
BLO-COLD Industrial Unit Coolers



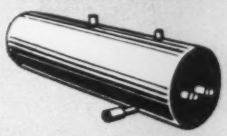
Dry-Ex Water Chillers



Pipe Coils

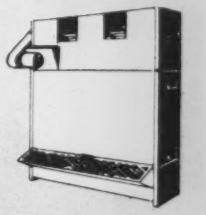


Shell and Coil Condensers



Oil Separators

Evaporative Condensers



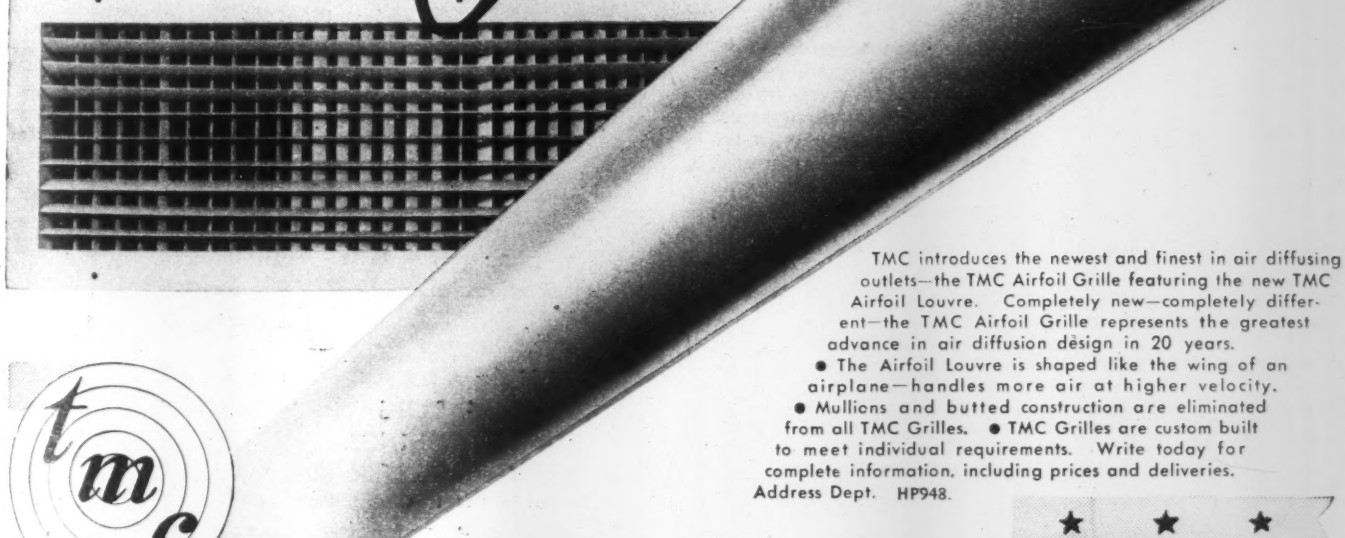
Heat Exchangers

Freon and Ammonia Condensers

Liquid Receivers

Air-foil

AIR DIFFUSING OUTLETS



TMC introduces the newest and finest in air diffusing outlets—the TMC Airfoil Grille featuring the new TMC Airfoil Louvre. Completely new—completely different—the TMC Airfoil Grille represents the greatest advance in air diffusion design in 20 years.

- The Airfoil Louvre is shaped like the wing of an airplane—handles more air at higher velocity.
- Mullions and butted construction are eliminated from all TMC Grilles.
- TMC Grilles are custom built to meet individual requirements.

Write today for complete information, including prices and deliveries. Address Dept. HP948.

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tmc

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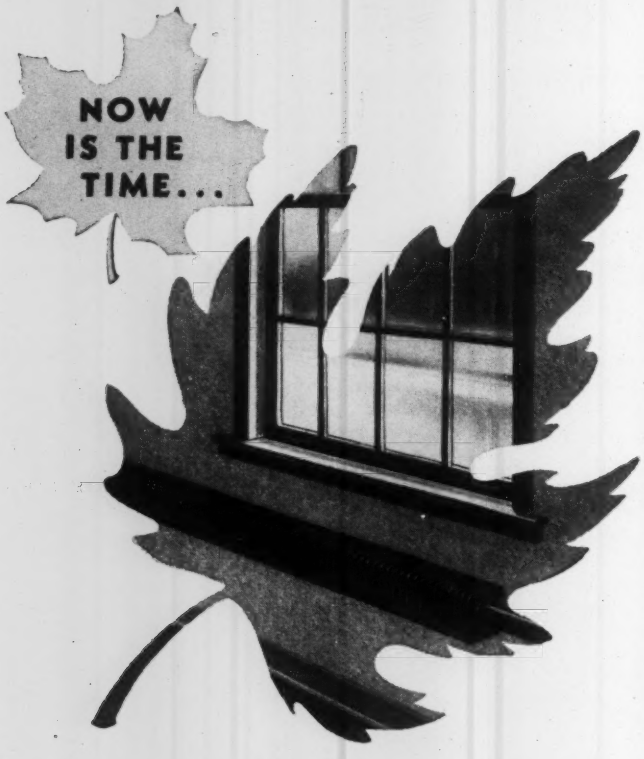
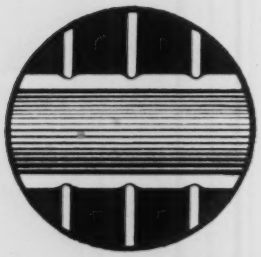


. . . to put VULCAN to work

Eliminate last year's "cold spots" and insure permanent heating comfort by supplementing existing systems with "a length of Vulcan" — by adding another length of Vulcan to take care of expanded living or working area — by replacing an inadequate system with Vulcan's compact continuous line radiation that gives more heat in less space — by installing a complete Vulcan system.

Vulcan meets practically every heating, design and installation requirement.

- Vulcan insures uniform heating comfort and at the same time makes an attractive installation that blends with interior design and decoration.
- Vulcan is light in weight and easy to handle on the job; requires few fittings and supports; comes cut to specified length with ends threaded or chamfered.



Fins Imbedded in Tube

Vulcan construction is sturdy — fins offset for rigidity (patented by Vulcan) are permanently imbedded in seamless steel pressure tube or copper water tube by a special process forming a perfectly bonded heating unit that requires no maintenance or upkeep.

Write today for details on performance and installation.

Vulcan-Hartford is stamped on every radiator.

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26 FRANCIS AVENUE
HARTFORD 6, CONN.
RADIATOR MANUFACTURERS FOR OVER TWO DECADES

hub, and split rim and hub types. Dimensions, list prices, and weights are tabulated, and information is given on key arrangements and the use of ball bearings.

Permanent Magnets

No. 6980—An eight page, illustrated bulletin (No. CDM-12) on permanent magnet assemblies and other metallurgical products has been issued by General Electric Co., Chemical Dept., Pittsfield, Mass. The bulletin is devoted to a description of cast and sintered "Alnico", "Cunife", "Cunico", "Vectolite", "Silmanal", and various permanent magnet holding assemblies. Special alloys such as "Thermistors" and "Hevimet" are also covered.

Power Drives for Light Machinery

No. 6981—Catalog CD-300 provides tabulated data on grooved, variable pitch, step cone, flush hub, and crown face pulleys, together with flexible couplings and fractional horsepower v belts. The manufacturer is Congress Drives Div., Tann Corp., 3750 E. Outer Drive, Detroit 12.

Products, Plants, and Personnel of Electrical Manufacturing Firm

No. 6982—A special edition of the house organ of Wagner Electric Corp., 6400 Plymouth Ave., St. Louis 14, Mo., briefly tells the story of the company as it is today. The 20 page, two color booklet contains illustrations of the company's personnel, plants, and products. A chart showing annual sales during the last 10 years graphically illustrates the growth of the company.

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JIFFY CLIPS

Do it Faster . . . Better!

Millions of "Duplex" Jiffy Clips have set an unsurpassed service-record for installing hanging pipe, conduit, B-X cable, coils, condensers, etc. One bolt or screw holds this ribbed clip. In zinc-plated steel or Everdur alloy.

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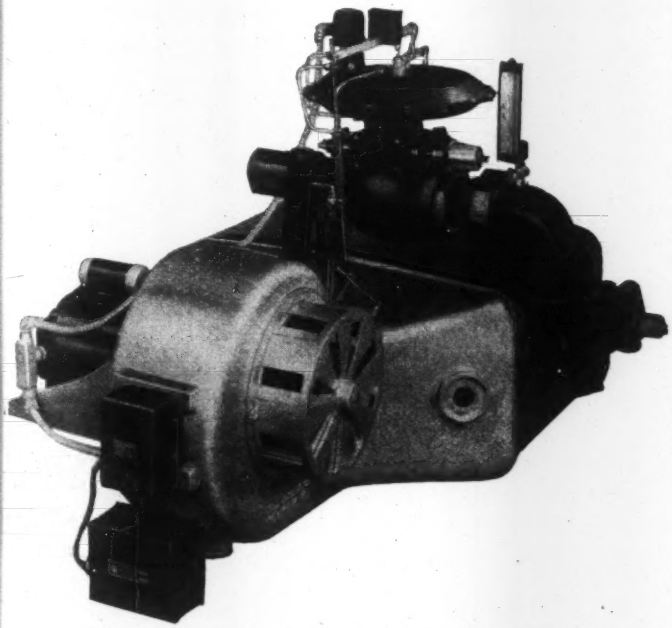
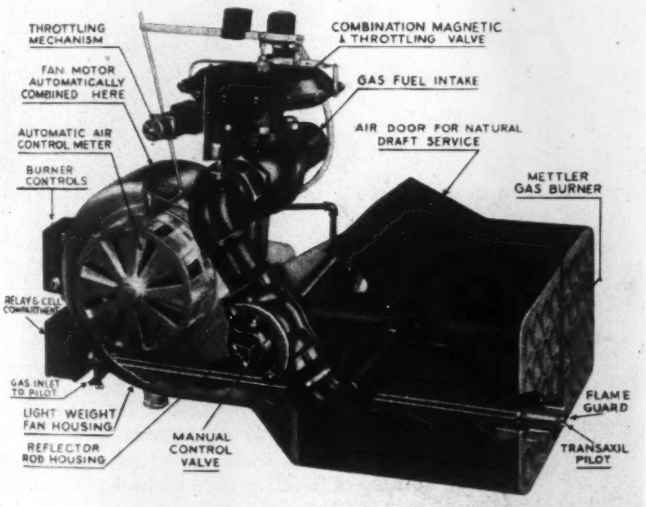
REG. U.S. PAT. OFF. EXPERTO CREDE

The Mettler "FAN-AIR" Gas Burner

LATEST MODEL FEATURES NEW AUTOMATIC SAFETY PILOT and TRIPLE CONTROLS



HERE IS A "FRONT VIEW" OF FAN-AIR GAS BURNERS (COMPACT AND SIMPLE)



Lower picture reveals essential and highly desirable POINTS of FAN-AIR MECHANICAL DRAFT GAS BURNERS. Not just a gas burner but a COMPLETE AND FULLY AUTOMATIC BURNER SYSTEM, factory tested and ready for application when received. It comes to you complete as pictured with simple, dependable, automatic controls. No other burner so easy to install. Why be satisfied with less—when all these tangible advantages are so readily available.

Worthy of sponsorship for Scotch Marine Boilers

SIZES 5 to 300 H.P. *PROMPT SHIPMENTS*

LEE B. METTLER CO.

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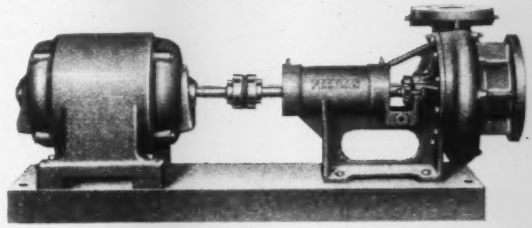
THE PEERLESS

Fluidyne

fmc PEERLESS PUMPS

THE ALL-AROUND ECONOMICAL GENERAL UTILITY CENTRIFUGAL PUMP

Type PB direct-connected to standard motor



HEADS: *Up to 270 feet*
DRIVES: *Fractional to 20 hp*
CAPACITIES: *Up to 1000 GPM*

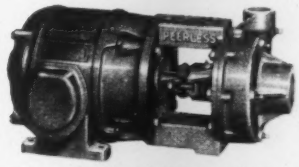
Durability – Economy – Plus Wide Utility for a Multitude of Services

The versatile Peerless Fluidyne is pumping simplicity at its best. Peerless FLUIDYNE Type PE (Electric drive unit) or the Type PB (direct connected, V-belt or flat belt drive unit) are designed for vertical, horizontal or intermediate angle installations, with consistent and dependable high efficiency operation. *Completely described in Bulletin B-165.*

FLUIDYNE FRACTIONAL HP PUMPS
¼ to 1 HP

CAPACITIES: *10 to 50 GPM.*
HEADS: *20 to 95 ft.*

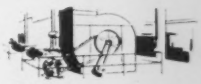
Possessing all characteristics of the Types PE and PB pumps described above, these fractional Fluidyne Peerless Pumps may be coupled to motor for incorporation into any system requiring forced liquid circulation. All Fluidyne pumps are of end suction, single stage design with vertical split casing joint, and embody a host of features for ease of accessibility and maintenance. *Completely described in Bulletins B-150 and B-151.*



Type PE Integral HP Electric Unit

FACTORIES

Peerless Fluidyne Types PE & PB are ideal for permanent or temporary installations in plants or factories. Small in size, easily moved, sturdy and dependable.



SYSTEM SUBASSEMBLIES

Fluidyne flexibility is readily adaptable as an integral part of equipment and system sub-assemblies in processing, refrigeration, air conditioning equipment, etc.

BUILDINGS

Builders and construction men can rely on Fluidyne's dependable service for their operations and for hotel, apartment and domestic layouts.

FOOD PACKERS

Fluidyne is handy for service in washers, coolers, cookers, etc. An excellent pump for liquid transfer. For continuous or intermittent service against head variations.

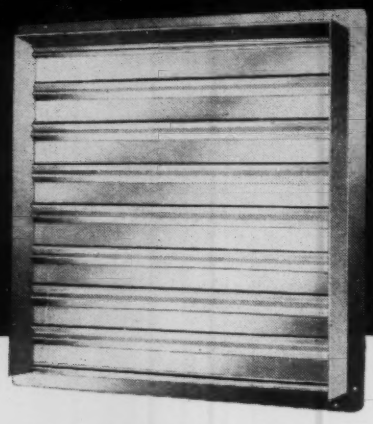
PEERLESS PUMP DIVISION

FOOD MACHINERY CORPORATION

FACTORIES: LOS ANGELES 31, CALIF.; INDIANAPOLIS, IND.

District Offices: New York 5, 37 Wall Street; Chicago 40, 4554 No. Broadway; Atlanta Office: Rutland Building, Decatur, Georgia; Dallas 1, Texas; Fresno, California; Los Angeles 31, California

they all want AIR-FLO



MODEL A-555

THE AUTOMATIC SHUTTER WITH ALL THE FEATURES

FRONT VIEW—CLOSED

IT TAKES THE LOAD OFF THE FAN!

Aluminum louvers open fully, permitting capacity fan operation. New heavy reinforcement strip adds strength and long life to the louvers, assures quiet operation and perfect counterbalance, prevents rattling. Deep shroud protects shutter from high winds. Tie-rod, brackets and bearings inside frame, not exposed to weather. Special finish resists corrosion. Many other features.

WRITE FOR NEW AIR-FLO CATALOG 43-D

Illustrations and details of the complete Air-Flo line.

AIR CONDITIONING PRODUCTS CO.
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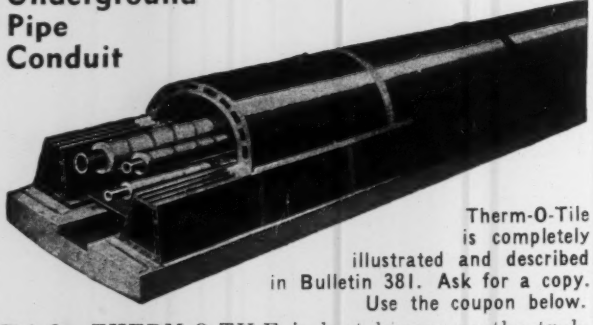
Ask for data on . . .
THERM-O-TILE
Reg. U. S. Pat. Off.

Underground Pipe Conduit



Therm-O-Tile is completely illustrated and described in Bulletin 381. Ask for a copy. Use the coupon below.

Briefly, THERM-O-TILE is best known as the truly *permanent* underground pipe conduit. Much stronger than required by A.S.T.M. Dry insulation, always. No sagging. No condensation pockets. Highest efficiency. Lowest ultimate cost. Even the *first cost* is competitive.

Sold and installed by Johns-Manville Construction Units in all Principal Cities.

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822-H Frelinghuysen Ave. Newark 5, N. J.

Without obligating us in any way, ☐ Please send Bulletin 381. ☐ Send representative. ☐ Enclosed is a sketch, with principal data of a prospective underground pipe conduit job, on which we shall be glad to have your ☐ comments ☐ quotations.

Name.....
Firm.....
Street.....
City..... State.....

Refrigeration Unit Selector Charts

No. 6983—The "Selectomatic" charts, available from Marlo Coil Co., 6135 Manchester Ave., St. Louis 10, Mo., are designed to provide a fast, accurate method of selecting the company's various refrigeration units. According to the company, all normal ranges are covered.

Relief Valves of Stainless Steel

No. 6984—A variety of safety and relief valves for the chemical industry are described and illustrated in a four page bulletin published by Associated Valve & Engineering Co., 1150 W. Marquette Rd., Chicago 21, Ill. Available in sizes up to 6 in. and for various pressures, the valves are offered in 316 stainless steel, aluminum, nickel, "Hastelloy", and other materials.

Sheaves and V Belts

No. 6985—Dimensions and prices of v belts and sheaves are tabulated in a 10 page catalog issued by Congress Drives Div., Tann Corp., 3750 E. Outer Drive., Detroit 12, Mich. Details of hubs, as well as interchangeable hub and rim combinations are covered, and the company's belts having steel cables instead of cotton cords are featured.

Small Sheet Metal Tools for Light Gage Work

No. 6986—Berkroy Products, Inc., 2516 N. Ontario St., Burbank, Calif., has published a 16 page booklet featur-

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• SEAMLESS—Constructed from one continuous piece of uniform thickness • PARALLEL CORRUGATION assures maximum strength and flexibility • SPECIAL ALLOYS provide resistance to heat, acid, etc., depending on requirements • AVAILABLE in wide variety of types to convey all kinds of liquids and gases • AVAILABLE in complete form as vibration reducers for Air Conditioning and Refrigeration Units.

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At-A-Glance readability from any direction; sizes to meet any tank requirements; sturdy, leak proof construction made to withstand high pressure; and UNDERWRITERS approval are plus values that make the Sentry gauge instantly acceptable with consumers everywhere. No intricate mechanism—easily installed. Write for complete details.

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GREEN BAY • WISCONSIN

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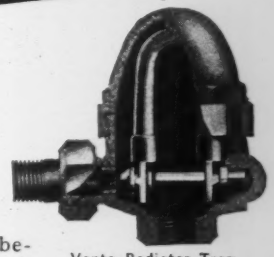
Cannot become air bound



Vento Radiator Trap

Haines Float and Thermostatic traps are designed to perform efficiently and safely under the most exacting conditions. They're made for low pressure jobs up to 20 lbs. in the ¾" size and 30 lbs. in the 1¼" sizes. They cannot become air bound, and the Haines underslung valve principle means safety at all times . . . no danger of building up a pressure. The famous Bourdon Thermostatic tube is used on all Haines traps . . . and is the strongest ever built into a steam trap. You can examine them under pressure, too . . . simply remove the cover and all working parts are before you. Please write now for more information.

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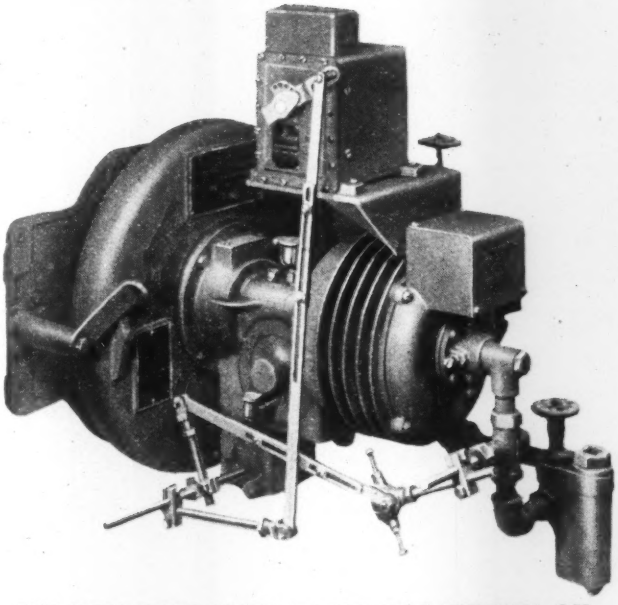

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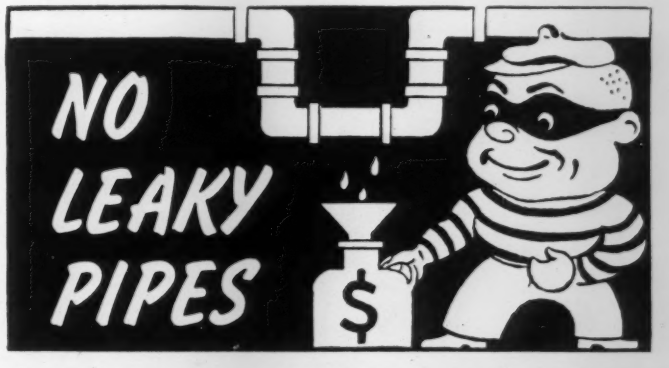

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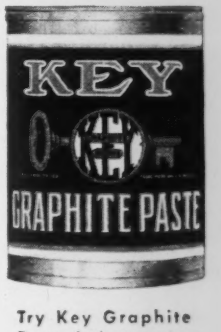

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If you expect to be in the market for stokers of any coal burning capacity between 50 and 2240 lbs. per hour, ask for data on Brownell Worm-Feed and Ram-Feed Stokers. Drop us a line while the subject is on your mind.

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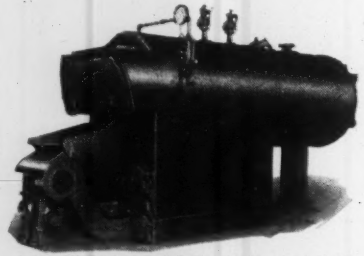

Brownell Stoker and Boiler in Matched Unit —the Ideal Installation

ing the various types of sheet metal work which can be done by using the five tools in the company's line. These small tools, which are designed for light gage work and which can all be mounted on a bench, include a nibbler, a brake, a shear, a slip roll, and a hand punch.

Small Welding Cylinders

No. 6987—New, small size cylinders for oxyacetylene welding have been introduced by Linde Air Products Co., Unit of Union Carbide & Carbon Corp., 30 E. 42nd St., New York 17, N. Y. Said to be particularly well suited to the needs of contractors, installers, and service men in the heating, ventilating, and air conditioning fields, they are also recommended for use in repair shops, sheet metal works, and many plants where welding and cutting are needed only for light and occasional work. The cylinders are described in two single page leaflets and a small folder.

Solenoid Contactors

No. 6988—Bulletin 4452 and 4453 covering the new size 2 and size 3 a-c solenoid contactors has been prepared by Ward Leonard Electric Co., 31 South St., Mount Vernon, N. Y. Designed expressly for use on a-c controllers for machine tools, pumps, fans, heating and ventilating systems, and other similar applications, the controls are said to feature double break silver contacts and built-in solderless connectors. Ratings are tabulated and dimensions are shown.

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Haney Venturi Gas Burners are the answer to all your heating installations whether commercial, domestic, or industrial. The vertical type illustrated will afford economical, even, dependable heat with remarkable freedom from maintenance troubles. It's shipped completely assembled, ready for installation and is available for mixed, natural or LP gases.

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New Vertical Unit for Underground Installation

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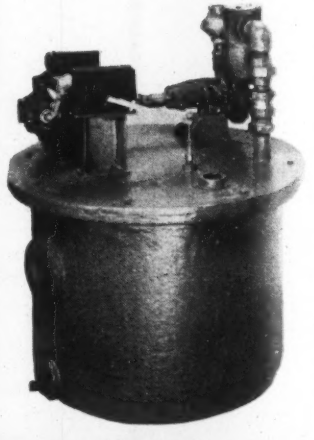

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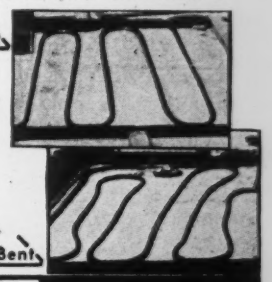

Tal Bender, Inc. Dept. 13 Milwaukee 2, Wis.

Announcing The SKIDMORE New Bulletin No. 19-A

Skidmore Type UV Pump is designed for use where returns are too low to permit the use of horizontal models.

★ Type UV Pump will operate very efficiently for the return of condensate from all types of steam heating or process equipment.

★ The UV Type Pump is also furnished in a Duplex Unit where system returns require the larger type pump.

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Full information and specifications in bulletin No. 19-A.
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GB fans ● manufactured for industrial ventilating and heating ● fume extraction ● forced draft ● induced draft ● Air-conditioning ● drying and processing, are of forward or backward curved wheel design.

Type F.C. are designed for quiet operation at low speeds. Type B.C. are designed to operate at high speeds and have the non-overloading characteristics.

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